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DEPARTMENT OF THE AIR FORCE
UNITED STATES OF AMERICA
MCMXLVII

DRAFT

Environmental Impact Analysis Process

OTH-B RADAR

Environmental Impact Statement
Proposed Sites
Central Radar System
Over-the-Horizon Backscatter Radar Program
August 1990

DEPARTMENT OF THE AIR FORCE

ELECTRONIC SYSTEMS DIVISION

--[redacted]--

REPORT DOCUMENTATION PAGE

Form Approved
OMB No 0704-0188

1. AGENCY USE ONLY *(Leave blank)*

2. REPORT DATE
AUGUST 1990

3. REPORT TYPE AND DATES COVERED
DRAFT 1990

4. TITLE AND SUBTITLE
Draft EIS for Proposed Sites Central Radar System Over-The-Horizon Backscatter Radar Program

5. FUNDING NUMBERS
Ø

6. AUTHOR(S)
USAF/Electronic Systems Division
HANSCOM AFB, MA.

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
—see Block 6—

8. PERFORMING ORGANIZATION REPORT NUMBER
Ø

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
USAF

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
Ø

11. SUPPLEMENTARY NOTES
N/A

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for Public Release; Distribution Is unlimited

12b. DISTRIBUTION CODE
A

13. ABSTRACT *(Maximum 200 words)*

DEIS supports siting CRS transmit & Receive facilities @ specific alternative locations w/in the Amherst, SD & Thief River Falls, Minn study areas

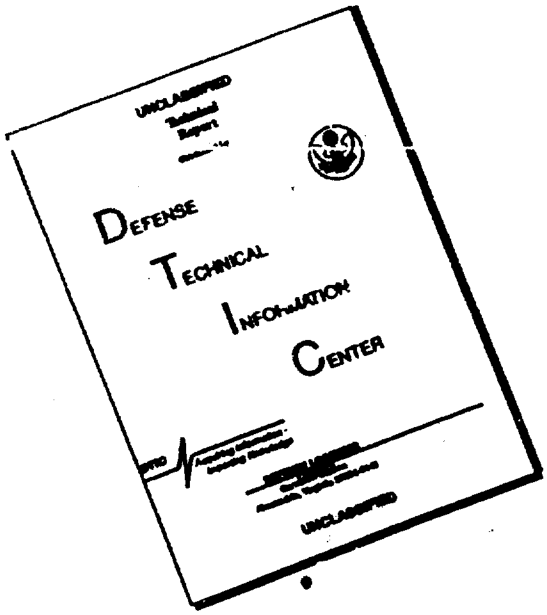
14. SUBJECT TERMS
OTH-B

15. NUMBER OF PAGES
250

16. PRICE CODE
Ø

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLAS	UNCLAS	UNCLAS	UL

DISCLAIMER NOTICE



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DRAFT
ENVIRONMENTAL IMPACT STATEMENT
PROPOSED SITES

CENTRAL RADAR SYSTEM (CRS)
OVER-THE-HORIZON BACKSCATTER (OTH-B) RADAR PROGRAM

Location - Brown, Day, and Marshall Counties, South Dakota; Sargent County, North Dakota; and Marshall, Pennington, and Polk Counties, Minnesota.

Lead Agency - U.S. Air Force

Cooperating Agency - Western Area Power Administration, U.S. Department of Energy

Contact at Lead Agency - Major Ronald L. Goodner, ESD/TBC, Hanscom AFB, MA 01731-5000, Telephone: (617) 271-5390

Comment Period - To Be Determined

Abstract - This Draft Environmental Impact Statement (DEIS) is tiered upon an EIS prepared by the Air Force in 1986-87 for the CRS. That EIS examined large study areas in western Minnesota and the eastern Dakotas for siting of OTH-B facilities. This DEIS investigates potential environmental effects from siting CRS transmit and receive facilities at specific alternative locations within the Amherst, South Dakota and Thief River Falls, Minnesota study areas. Two preliminary site layouts for transmit facilities at the Amherst Study Area and alternative corridors for powerlines are studied, as are two site layouts and alternative powerline corridors for CRS receive facilities at the Thief River Falls Study area.

The environmental analysis determined that some significant adverse impacts could result if CRS is constructed at either transmit site, depending on the effectiveness of mitigation measures. Potentially significant adverse impacts that could result at either site include dust generation, bird collisions with CRS antennas, hydrologic changes, destruction of the Western prairie fringed orchid (a threatened species) if it occurs at the transmit site, and degradation of the visual setting of historic properties. More wetlands would be filled at Tx-N than at Tx-S. There would be no significant difference in environmental impacts between the two alternative site layouts, consequently neither alternative is environmentally preferred over the other.

Environmental analysis of the alternative receive sites layouts determined that significant adverse impacts could result if CRS is constructed at either site. Potentially significant adverse effects on hydrology and wetlands, on endangered species if they occur on site, on historic properties, on air quality from dust generation, and on birds from collision potential could occur, depending on the effectiveness of mitigation measures. Because impacts on historic properties and federally listed species could be greater at the eastern alternative site layout, the western alternative site layout is environmentally preferred.

SUMMARY
Environmental Impact Statement (EIS) For The OTH-B Central Radar System (CRS)

Background

The Over-the-Horizon Backscatter (OTH-B) radar is a surveillance and tracking radar system planned for four locations in the United States. The CRS will, in conjunction with the East Coast, West Coast, and Alaskan radar systems, provide early detection of hostile aircraft approaching North America. CRS site-selection studies began in the early 1980s. Nine potential areas for siting of CRS transmit and receive facilities were examined in a 1986 Draft EIS and a 1987 Final EIS. This EIS is tiered upon the earlier EIS. A Record of Decision issued in 1988 selected the Amherst, South Dakota study area for the transmit facilities and the Thief River Falls, Minnesota study area for the receive facilities and determined that additional environmental assessment of specific sites would be necessary. Considering operational, environmental, and socioeconomic criteria, two alternative preliminary site layouts within the Amherst study area (labelled Tx-N and Tx-S) and two alternative preliminary site layouts within the Thief River Falls study area (labelled Rx-E and Rx-W) were defined for the CRS transmit and receive facilities, respectively. Those alternative study areas are examined in this EIS. The 1988 ROD also determined that construction and operation of the CRS operations center at Grand Forks AFB, North Dakota would not cause significant environmental impacts, therefore the operations center is not analyzed in this EIS.

Project Description

The CRS will consist of an operations center at Grand Forks AFB, North Dakota, transmit facilities at one of the two alternative sites in South Dakota, and receive facilities at one of the two alternative sites in Minnesota. The transmit facilities will consist of four sectors, each with an approximately 5,000-ft antenna including a sounder antenna, a 750-ft-wide groundscreen in front

of each antenna, a 15,000-17,000-ft^2 equipment building, a two-car garage and parking area, and fuel and water storage tanks. Each antenna sector will also include a 4,000-ft by 5,000-ft exclusion area surrounded by an 8-ft wooden fence and a perimeter road. Two 115-kV powerlines connecting to the existing substations near Forman, North Dakota and the Groton, South Dakota will supply electric power.

The receive facilities will also have four sectors, each with a 5,012-ft long antenna and a 750-wide groundscreen, a 4,200-8,000-ft^2 equipment building, a parking area, and fuel and water storage tanks. Each sector will be surrounded by an 8-ft wooden fence and a perimeter road. Power would be supplied to Rx-E by a 7.2-kV or 12.47-kV powerline connecting to either the Morris Owen or the Dakota Junction substation of Red Lake Electric Cooperative, and to Rx-W by a 7.2-kV or 12.47-kV powerline connecting to the Radium Substation of PKM Electric Cooperative.

Construction employment for the CRS transmit and receive facilities would peak at 220. During operation, about 25 persons in 3 daily shifts of 5-6 would be employed at each site.

Construction of the initial two receive and transmit sectors will begin in 1991 and will be completed in 1994, at which time testing of the system will begin. Construction of the the final two sectors is planned for the period 1993-97. The CRS will operate for at least 20 years.

Alternatives

Airborne Warning and Control Systems (AWACS) and satellites were considered as possible alternatives to OTH-B. A large number of AWACs at prohibitive cost would be necessary to provide surveillance coverage of the over 4 million mi^2 that will be covered by the CRS. Surveillance satellites do not now have the capability to cover large areas with the same resolution as the CRS. Development of that capability will take 8-10 years. It is also expected to be much

more expensive than the CRS. Consequently, AWACs and satellite systems are not feasible alternatives to the CRS.

The no-project alternative was examined in the 1986-1987 EIS. The 1988 ROD rejected that alternative because the essential objectives being satisfied by the CRS would not be achieved.

Environmental Effects and Mitigation Measures

Geology and Soils

Construction of CRS transmit and receive facilities will require stripping of vegetation and grading on about 504-511 acres at the transmit site and on about 527 acres at the receive site. During powerline construction, soil disturbance will result from digging of pole holes and trenching to place portions of the lines underground. For transmit-site powerline construction, about 5 acres will be disturbed. For receive-site powerline construction, the disturbed area will be less than 2 acres for an aerial powerline and up to 27 acres for an underground powerline. The amount of fill emplaced will be 863,000-1,435,000 yd^3 at the transmit site and 1,222,000-1,706,000 yd^3 at the receive sites. Wind and water soil erosion at construction areas can be reduced by erosion control measures. Off-site sources of fill are not known at this time, but the amount of imported fill will be minimized by balancing cut and fill on site and re-using cut material as much as possible. No substantial topographic alterations or effects on mineral resources will result.

Hydrology and Water Quality

Construction of impervious surfaces and changes in ground slope would increase storm runoff at Tx-S, Rx-E, and Rx-W; runoff rates would not increase at Tx-N. In addition, depressions which naturally store flood waters would be filled, reducing flood-storage capacity by 670 acre-feet at Tx-N, 1,700 acre-feet at Tx-S, 38 acre-feet at Rx-E and 10 acre-feet at Rx-W. The

site drainage systems will include detention basins to compensate for lost flood storage capacity and the project would not result in higher downstream runoff or increased flood hazards.

Substantial runoff from off-site upstream areas flows across the alternative sites. The maximum post-construction flow per sector that would be routed around the CRS site would be about 750 cfs at Tx-N, 1,220 cfs at Tx-S, 800 cfs at Rx-E, and 1,650 cfs at Rx-W, but could be less if other measures are used to control runoff.

Projected water consumption will be 50,000-100,000 gpd during construction and 3,000 gpd during operation for both the transmit and receive facilities. Groundwater wells will supply project water needs, drawing upon the James or the Dakota aquifer at the transmit site and an unnamed aquifer within glacial till at the receive site.

Soil erosion and sedimentation of natural water bodies could cause a minor temporary increase in turbidity. Measures to reduce erosion would minimize that impact. Additionally, potential contaminants, such as paints, solvents, and cleaners, used during construction and operation could, with improper storage and disposal, adversely affect water quality. A Spill Prevention, Containment, and Countermeasure plan will be developed to minimize that hazard. With implementation of mitigation, project impacts on turbidity and water contamination should be minimal.

Depending on the routes selected for transmit- and receive-site powerlines, some powerline structures could be located in wetlands or near stream channels. Adverse wetland impacts could result from direct disturbance or improper disposal of excess soil. Siting powerline structures to avoid wetlands would minimize those impacts.

Air Quality

Dust will be generated at all construction sites by wind erosion of exposed soil, earth moving, and vehicle travel on unpaved surfaces. During site preparation, daily emissions of dust particles smaller than 10 microns in diameter (PM_{10}) will be 78,000-82,000 lb/day at the transmit site and 96,000-114,000 lb/day at the receive site. The 24-hr federal standard for ambient PM_{10} concentrations (150 $\mu g/m^3$) will probably be temporily exceeded at the construction sites and in downwind areas.

Construction equipment, haul trucks, and workers' automobiles would emit carbon monoxide, hydrocarbons, nitrogen oxides, and sulfur oxides. Concentrations of those pollutants are not expected to exceed federal and state standards. Similar air pollutants will be generated during CRS operation by vehicles used by the operating staff and by security patrols, but no federal or state standards will be exceeded.

Noise

During CRS construction, noise levels could reach 89 dBA at the site. At a distance of 0.5-1.0 mi from the site, the noise level would be about 57 dBA. Construction noise levels would be more than 5 dBA above existing noise levels, which would be a significant impact on nearby residents. In addition, several hundred haul truck trips per day to transport fill to the site would subject residents along haul routes to elevated noise levels. Similarly, construction of the powerlines would elevate noise levels at tower and substation sites. Very little noise will be generated during CRS operation and no significant noise impacts will result.

Electromagnetic Interference

The CRS signal could interfere with other electromagnetic signals using the same frequency band or a harmonic of the CRS band. CRS will transmit within the 5-28 MHz band, selecting frequencies which are apparently not being used. Because CRS will be operated to avoid

frequencies which are in use, the likelihood of interference with fixed point communications links and amateur radio is very low. CRS could cause fundamental overload or high-power interference effects on televisions within several miles of the transmit site. Those effects could be prevented by installation of appropriate filters on the television antenna or set. Tests of the OTH-B Experimental Radar System indicate that CRS would interfere with land-mobile radio and broadcast radio only within 3 and 2 mi of the transmit site, respectively. CRS could also interfere with functioning of air navigation and communication equipment, including VORTACs, VOR/DMEs, and non-directional beacons. To reduce that hazard, the CRS would refrain from transmitting on subharmonics of VOR frequencies and would request that the Federal Aviation Administration publish a Notice to Airmen about CRS.

The CRS signal could also affect cardiac pacemakers, but the distance at which pacemakers could be affected is within the exclusion area, therefore no impact will result. The CRS would also be capable of causing premature firing of electroexplosive devices. The Air Force will notify state and local governments of that hazard so that appropriate precautions can be taken.

Biological Effects of Radiofrequency and Powerline Field Radiation

To investigate the potential for radiofrequency radiation (RFR) to cause human health effects, the Air Force funded a major review of over 500 technical papers on the subject. That review has since been updated and is summarized in this EIS. The study examined possible RFR effects in the area of epidemiological and occupational studies, congenital anomalies, ocular effects, RFR shock and burn, mutagenesis, cytogenetic effects, carcinogenesis, teratogenesis, nervous-system effects, immunology and hematology, physiology and biochemistry, endocrinology, cardiovascular effects, behavior, and cellular and subcellular effects.

The review determined that most reported effects were due to tissue heatings. The 1982 American National Standards Institute (ANSI) and the proposed 1990 Institute of Electronics and

Electrical Engineers (IEEE) revision of that standard are designed to prevent such body heating. The CRS conforms with those standards by establishing a large exclusion area. Outside the exclusion area, the power levels would be well below the levels set by those standards for human exposure to RFR.

Some researchers have reported non-thermal affects from RFR at the cellular and sub-cellular level. However, it is difficult to extrapolate those findings to entire organisms. Nonetheless, there is no conclusive evidence that chronic exposure to RFR within the levels set by the ANSI standard or the proposed IEEE revised standard would result in harmful human health effects.

Small animals and birds could enter the area within the exclusion fence. But, they would absorb relatively little RFR, no harmful effects to wildlife are expected.

Some scientific studies have linked powerline electric and magnetic fields with biological effects, including cancer in humans. Many other studies have produced no evidence that powerline fields are harmful to human health, and current scientific knowledge is inadequate to prove or disprove such claims. The powerlines constructed for the CRS transmit and receive sites would be in conformance with state and National Electric Safety Code standards for the strength of electric and magnetic fields within ROWs. No adverse impacts to human health are expected.

Biotic Resources

Possible direct impacts on vegetation and wetlands are listed in Table S-1. The removal of winter habitat for deer would occur at Tx-N, Tx-S, and Rx-E. Little deer habitat occurs at Rx-W. Loss of that habitat would be a minor impact. The Federal goal of no net loss of wetlands requires that the functional value of affected wetlands be replaced by creation, restoration, or enhancement of new or existing wetlands, preferably in an amount equal to the disturbed wetlands. The Air

Force will conform with those regulations; details of wetland mitigation will be developed in consultation with the U.S. Army Corps of Engineers and federal and state wildlife agencies.

Construction of CRS would affect leks for the sharp-tailed grouse and greater prairie chicken at Tx-N and Rx-E. E Large numbers of geese, duck and many other bird species migrate through both the transmit and receive study areas, creating a high potential for collisions with the antennas, particularly at night or during bad weather. The antenna designs have been modified to enlarge the backscreen openings to reduce the likelihood of avian deaths or injuries.

Twelve species occurring in the vicinity of the transmit study area and 14 species which may occur in the vicinity of the receive study area are considered threatened or endangered by the U.S. Fish and Wildlife Service or state wildlife agencies. The presence of most of those species

Table S-1
VEGETATION REMOVAL AND WETLAND FILLING

	Removed Vegetation (acres)				
Alternative Site	Native Rangeland	Woodland	Cropland	Grassland	Filled Wetlands (acres)
Tx-N	438	-	-	-	62
Tx-S	-	5	440	34	23
Rx-E	245	-	267	-	15
Rx-W	-	1	447	75	4

Source: Metcalf & Eddy/Holmes & Narver, 1990D.

has not been confirmed. Bald eagles and peregrine falcons, both federally listed as endangered, have been sighted at both the transmit and receive study areas. The Air Force has requested, but has not yet received, a biological opinion from the U.S. Fish and Wildlife Service concerning

possible effects on those species. Ospreys and buff-breasted sandpipers, species of concern in South Dakota, have been seen only at the transmit study area while piping plovers, federally listed as threatened in Minnesota, historically have been sighted at the receive study area. Because few have been observed, significant impacts on ospreys or buff-breasted sandpipers are unlikely. The Air Force has determined that there will be no effect on the piping plover at either the transmit or the receive sites. The U.S. Fish and Wildlife Service has concurred with that conclusion for the transmit site, but has not yet commented for the receive site. The Air Force has determined that there will be no effects on the whooping crane and the Eskimo curlew, both listed as endangered at the transmit study area. The Air Force and the U.S. Fish and Wildlife Service have also determined that there will be no effect on the gray wolf, feuerally listed as threatened at the receive site. The Air Force is unable to make a determination on whether the project will affect the Western Prairie Fringed Orchid, federally listed as threatened, and the American burying beetle, federally listed as endangered, at the transmit study area. Field surveys for those two species have been conducted recently and biological assessments are under preparation. Several state-listed species may occur at wetlands at the transmit sites, but that has not been confirmed, although the potential for impacts is higher at Tx-N than at Tx-S. At the receive study area, three plants listed as threatened by the state of Minnesota, and a butterfly, listed as endangered by the state of Minnesota, could occur in wetlands. The presence of those species at the sites is uncertain, but the potential for their occurrences would be greater at Rx-E than at Rx-W.

Aesthetics

The CRS antennas and related structures will be visible for a considerable distance due to their large size. Visual impacts on nearby historic properties could result if they are eligible for listing on the National Register of Historic Places (NRHP) and their eligibility depends substantially on their setting. Tx-N is within 1 mi of the Columbia Stage Trail and half-way house while Tx-S is about 3 mi from the Johnson and Swenson homesteads. Rx-E is within 0.25 mi of

the Woods/Pembina Historic Trail and several other historic properties. No historic structures near Rx-W are known. Thus, potentially significant visual impacts on historic properties could result from building CRS facilities at Tx-N, Tx-S or Rx-E.

Visual impacts could also result from contrasts with the existing landscape. At all four of the alternative transmit and receive sites, the antennas would create a weak to moderate contrast with the existing landscape, which would be a minor impact.

The powerlines supplying the transmit and receive sites would be similar to and possibly parallel to existing powerlines over much of their routes. For the transmit-site powerline, Link 7 has the hilliest terrain and the highest potential for impacts due to skylining. In addition, numerous historic properties occur along various links and could be visually affected. On the other hand, because the receive-site powerlines would be constructed in a moderate- to- high-compatibility landscape and will generally parallel existing powerlines, no significant visual impacts would be expected from an aerial powerline. An underground powerline would not cause visual impacts.

Land Use

The principal land-use effect will be the removal of land from agricultural use. At the transmit site, about 1,600 acres will be removed from production for the operational life of CRS, representing less than 1% of the farmland in Brown and Marshall counties, South Dakota. At the receive site, 850-1,000 acres will be removed from agricultural use, representing less than 0.5% of the farmland in Pennington or Polk Counties, Minnesota. Farming could continue within powerline rights-of-way; no significant impact on land use would result.

Recreation

Hunting and other outdoors activities will not be permitted at the CRS sites. No impacts on established parks or recreation areas will result.

Socioeconomics

At both the transmit and the receive sites, the removal of land from agricultural production will result in a decrease in personal income of $75,000-$110,000 and loss of 6-10 jobs. Those effects would be offset by CRS construction and operations employment. During construction, the net direct gain at each site would be about $2,900,000 in personal income and 110 jobs. During CRS operation, the net direct gain at each site would be about $390,000 in personal income and 15 jobs.

A temporary immigration of workers to the transmit and receive sites during CRS construction is expected. A much smaller permanent inflow of residents could occur during CRS operation. The existing housing stock has ample capacity to meet those influxes.

Land purchased for the CRS will be removed from local property-tax rolls. Some parcels may be leased, in which case they would continue to provide property tax revenues to local governments. If all land for CRS were purchased, the decrease in property tax revenues to Brown and/or Marshall counties in South Dakota and Pennington or Polk counties in Minnesota would be 0.2-0.7%. The decrease in revenues to local school districts would be 0.1-1.1%, which would not be a significant impact.

Transportation

Construction of CRS would require closing of local dirt and gravel roads at the selected sites. More roads would have to be closed at Tx-S than at Tx-N and more at Rx-W than at Rx-E. No paved roads would have to be closed at any of the sites. The Air Force will allow public use of the CRS perimeter roads where existing public roads have been closed.

Haul trucks and construction vehicles will make many trips during construction. The level of service (LOS) of a number of state and county roads near the sites will be reduced from A to C. That change will be a minor impact because LOS C is considered acceptable.

Powerline construction will also generate trips by trucks, heavy equipment, and workers, but the trips will be distributed over the length of the lines and will not significantly affect the LOS of local roads.

Cultural Resources

CRS construction could result in direct impacts on artifacts and in visual impacts to nearby historic properties. At Tx-N, an estimated 23 archaeological sites could occur, but none is expected to be significant. The Columbia Stage Trail and related facilities are about 1 mi from Tx-N. At Tx-S, an estimated 50 archaeological sites could occur; again, none is expected to be significant. Depending upon their eligibility for the NRHP, significant impacts could occur on the Johnson and Swenson homesteads, which are potential historic properties within 3 mi of Tx-S.

Resource density is expected to be very high at Rx-E and low at Rx-W. In particular, historic properties are highly likely along the beach ridges of glacial Lake Agassiz near Rx-E. The Woods/Pembina Trail and several other historic properties are within 1 mi of Rx-E and could experience visual impacts. No impacts are expected at Rx-W. To mitigate potential impacts, a 100% pre-construction survey of the selected sites will be undertaken. Sites uncovered by that survey will be recorded and evaluated in conformance with the CRS Programmatic Agreement.

Resource density for Links 7-10 of the transmit-site powerline corridors is expected to be 1.2-1.5 sites per 1,000 acres; resource density at Links 1-6 is expected to be lower. Historic cultural resource potential is estimated at two sites per mile. Physical impacts on archaeological resources could result during construction, and visual impacts from powerlines could affect the setting and eligibility for NRHP of historic structures. Most impacts would be prevented through proper route selection.

All powerline corridors connecting to Rx-E cross beach ridges, which have a high potential for cultural resource sites. Artifacts could be destroyed during erection of powerline structures for an aerial powerline or trenching for an underground line. The Rx-W powerline corridor has a somewhat lower potential for sites. The receive-site powerlines would probably be located parallel to roads and existing powerlines, reducing the potential for impacts on archeological resources.

Comparison of the Environmental Consequences of the Alternatives

Construction of CRS transmit facilities at either Tx-N or Tx-S could result in significant impacts to air quality from wind erosion and dust emissions during project construction, birds from collisions with antennas, wetlands from filling, sensitive plant species if they occur at the sites, and historic properties from changes in viewshed. More wetlands would be filled at Tx-N than at Tx-S, but greater alterations to surface runoff flow and flood-storage capacity, and loss of more prime farmland would occur at Tx-S. No clear environmental preference between the two transmit-site layouts is indicated by these expected impacts.

Construction of CRS receive facilities at either Rx-E or Rx-W will result in significant or possibly significant air quality impacts from dust generation during construction; biological impacts from the potential for birds to collide with antennas and the filling of wetlands; and hydrologic impacts from drainage changes. However, several threatened and endangered species and cultural resources are more likely to occur at Rx-E. Therefore, Rx-W is environmentally preferred to Rx-E.

Powerlines will connect the CRS transmit site to existing substations at Groton, South Dakota and Forman, North Dakota. For Tx-N, use of Links 1 and 3 to connect to the Groton substation would minimize the number of stream crossings. Impacts on other environmental and cultural resources would be similar to those for the alternative links. To connect Tx-N to the Forman substation, Links 5, 6 and 9 contain less wetland acreage and fewer stream crossings than

the alternative links. Impacts on grasslands, irrigated farmland, birds, and visual resources are also expected to be less for Links 5, 6 and 9 than the alternative links. Thus, Links 1, 3, 5, 6, and 9 are environmentally preferred for the Tx-N powerlines.

For Tx-S, Link 1 would involve fewer stream crossings than use of Link 2, making Link 1 environmentally preferred for the powerline connecting Tx-S to the Groton substation. For the powerline between Tx-S and the Forman substation, use of Links 3, 5, 6,and 9 would minimize impacts on streams, wetlands, grasslands, and urban land uses and therefore are environmentally preferred.

Three alternative corridors were investigated for the Rx-E powerline. Use of the corridor connecting to the Dakota Junction substation would result in fewer impacts on wetlands, urban land uses, and visual resources; thus it is environmentally preferred over the two corridors connecting to the Morris Owen substation. Only one powerline corridor was analyzed for Rx-W because of the relatively short distance between the Radium substation and the site. No significant environmental impacts would be expected from construction of the powerline in that corridor.

Irretrievable Commitment of Resources and Long-term Productivity of the Land

Construction of the CRS will consume materials and fuels in amounts that will not be significant at the regional or national level. The CRS will also occupy about 2,600 acres for a construction period of several years and an operation period of 20 years or more. Allowable land uses will also be restricted within about 1,400 acres of the powerline ROW. The reduction in farmland and wildlife habitat will be minor impacts.

About 511 acres at the transmit site and 527 acres at the receive site will be disturbed for construction of CRS facilities. Between 8-32 acres will be disturbed for powerline construction and substation expansion, depending on whether the receive-site powerline is above ground or buried. The land involved is primarily farmland, and its removal from production will cause a small decrease in arable land.

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GLOSSARY

Abbreviations and Units of Measure

AAMI	Association for Advancement of Medical Instrumentation
ac	Alternating Current
acre-ft	Acre-feet
ADT	Average Daily Traffic
AFB	Air Force Base
AFOSH	Air Force Occupational Safety and Health
AFR	Air Force Regulation
agl	Above ground level
AM	Amplitude modulation
ARC	Atlantic Resource Corporation
ARS	Alaskan Radar System
AWACS	Airborne Warning Control System
BMP	Best Management Practice
cfs	Cubic feet per second
CNEL	Community Noise Equivalent Level
CO	Carbon Monoxide
COE	U.S. Army Corps of Engineers
CRMP	Cultural Resources Management Plan
CRP	Conservation Reserve Program
CRS	Central Radar System
CSA	Concentrated Study Area
CW	Continuous wave
dB	Decibel
dBA	A-Weighted Decibel
DC	Direct Current
DME	Distance Measuring Equipment
DOA	Department of Agriculture
DOE	Department of Energy
ECRS	East Coast Radar System
eed	Electroexplosive device
EEG	Electroencephalogram
EIAP	Environmental Impact Analysis Process
EIS	Environmental Impact Statement
EMF	Electromagnetic Fields
EMI	Electromagnetic Interference
EMR	Electromagnetic Radiation
EPA	Environmental Protection Agency
ERS	Experimental Radar System
ESD	Electronic Systems Division (USAF)
FAA	Federal Aviation Administration
FDA	Food and Drug Administration
FEMA	Federal Emergency Management Agency
FM	Frequency modulation
FM/CW	Frequency - Modulated/Continuous Wave
ft	Foot
ft^2	Square feet
Gal	Gallon
GHz	Gigahertz

GLOSSARY

Abbreviations and Units of Measure

g/l	Grams Per Liter
gpd	Gallon per day
gpm	Gallon per minute
GSA	General Services Administration
H_2S	Hydrogen Sulfide
HF	High frequency
Hr	Hour
in^2	Square inch
ISC	Industrial Source Complex
kHz	Kilohertz
kW	Kilowatt
kWH	Kilowatt Hour
kV	Kilovolt
LB/d	Pound Per Day
Ldn	Day-Night Equivalent Noise Level
Leq	Energy Equivalent Noise Level
LOS	Level of Service
m	Meter
M	Micron
mG	Milligauss
MARS	Military Affiliate Radio System
mg/l	Milligram Per Liter
$\mu g/m^3$	Microgram Per Cubic Meter
MHS	Minnesota Historical Society
MHz	Megahertz
mi	Mile
MPCA	Minnesota Pollution Control Agency
MPH	Miles Per Hour
m/s	Meters Per Second
msl	Mean Sea Level
MW	Megawatt
mW/cm^2	Milliwatts per square centimeter
MV	Microvolt
NAAQS	National Ambient Air Quality Standards
NDB	Nondirectional Beacon
NEPA	National Environmental Policy Act
NESHAPS	National Emission Standard for Hazardous Pollutants
NIEMR	Nonionizing Electromagnetic Radiation
nmi	Nautical mile
nmi^2	Square nautical mile
NO_2	Nitrogen Dioxide
NOTAM	Notice to Airmen
NRHP	National Register of Historic Places
NTIA	National Telecommunication and Information Agency
O_3	Ozone
OTH-B	Over-The-Horizon Backscatter
PA	Programmatic Agreement
Pb	Lead

GLOSSARY

Abbreviations and Units of Measure

PM	Particulate Matter
PPS	Pulses Per Second
RF	Radiofrequency
RFR	Radiofrequency radiation
ROD	Record of Decision
ROW	Right of Way
RV	Recreational Vehicle
Rx-E	Eastern CRS Receive Site
Rx-W	Western CRS Receive Site
s	Second
SAR	Specific absorption ratio
SCS	U. S. Department of Agriculture Soil Conservation Service
SDDGFP	South Dakota Department of Game, Fish and Parks
SDDWNR	South Dakota Department of Water and Natural Resources
SHPO	State Historic Preservation Office
SIP	State Implementation Plan
SO_x	Sulfur oxide
SPCC	Spill Prevention, Containment, and Countermeasure Plan
T	Ton
TACAN	Tactical Air Navigation System
TSP	Total Suspended Particulates
t/yr	Tons Per Year
Tx-N	Northern CRS Transmit Site
Tx-S	Southern CRS Transmit Site
UHF	Ultra-High Frequency
USAF	United States Air Force
USDA	U. S. Department of Agriculture
USFWS	U.S. Fish & Wildlife Service
VHF	Very High Frequency
V/M	Volts/Meter
VMT	Vehicle Miles Traveled
VOR	Very High Frequency Omnirange
VORTAC	Co-allocated Very High Frequency Omnirange and Tactical Air Navigation System
WARF	Wide Aperture Research Facility
WAPA	Western Area Power Administration
WCRS	West Coast Radar System
W/kg	Watts/Kilogram
W/m	Watts Per Meter
W/m^2	Watts Per Squaremeter

GLOSSARY

Definitions

Airspace	The portion of the atmosphere directly above a piece of land
Alluvial/Alluvium	Pertaining to all detrital river sediments
Archeological	Relating to the study of material remains of past human life and activities
Argillite	A sedimentary rock whose degree of induration sometimes makes it suitable for stone tool manufacture
Assemblage	The sum total of artifactual materials recovered from an archeological site
Avian	Pertaining to birds
Basement rock	Complex of igneous and metamorphic rocks overlain by sedimentary layers
Beach ridge	A topographic feature composed of sand deposited at the edge of an ancient lake
Biface	A stone artifact bearing flake scars on both faces
Bituminous	A road surface formed out of tar or other hydrocarbons
Blade	A specialized flake with parallel or subparallel lateral edges; the length being equal to, or greater than the width.
Blackbirds	All species of blackbirds, meadowlarks, orioles, and starlings
Blacksoil prairie	Grasslands with deep organic-rich soil
Blowout	A hollow formed by wind erosion of sandy soil
Brady cardia	Relatively slow heart action
Browse	To feed on tender shoots, leaves and twigs of trees and shrubs
Burin	An implement manufactured from a flake, blade or other lithic object by removal of an edge such that the resultant facet, or flake scar, forms a right angle on one or both margins
Candidate species	Formally under consideration by USFWS for designation as endangered or threatened
Carcinogenesis	The initiation or promotion of cancer
Chert	A sedimentary rock rich in silica

GLOSSARY

Definitions

Cobble	A rock fragment between 64 and 256 millimeters in dia- meter, larger than a pebble and smaller than a boulder
Collection time	The period of time required for precipitation to flow from the most distant part of a land area to the drainage outlet
Complex	Configurations of associated cultural traits which are restricted both chronologically and regionally. Complex closely corresponds to the earlier term "phase"
Component	A collection of artifacts within an artifact assemblage, or physical manifestation within an archeological site which indicates a distinct period of occupation
Conductor	The wire used to transmit electricity in powerlines
Corona	A faint glow adjacent to the surface of a high voltage conductor
Craton	The relatively stable interior portion of a continent
Deciduous	Vegetation which sheds leaves annually
Detention basin	A surface depression used to temporarily store runoff to reduce the height of downstream flows
Diagnostic artifact	An artifact possessing attributes of form or manufacture associated with a complex or tradition
Dissolved oxygen	The amount of oxygen contained in water
Diurnal	Belonging to the daytime
Easement	An arrangement that allows limited use of land by someone other than the owner
Electromagnetic	Pertaining to electric and magnetic fields
Embryogenesis	The development of a vertebrate prior to birth
Emergent	Vegetation which may be flooded at the base but extends above the water line and will not tolerate long-term submergence in water
Endangered	USFWS's highest classification for a species which is limited in numbers or extent; on the verge of extinction
Endocrinology	The study of glands which make internal secretions within the body
Eolian	Related to the wind

GLOSSARY

Definitions

Ethnohistoric	Refers to the integration of early historic documentation with ethnographic information of the same period to construct a more complete characterization of a culture
Euroamerican	Refers to non-Native individuals and events
Evapotranspiration	The return of water to the atmosphere through evaporation or vegetative transpiration
Exclusion area	The area within the CRS perimeter fence that will not be accessible to the public
Feature	Cultural and "nonportable" physical manifestations such as hearths, cache pits, etc.
Flake	A fragment of rock intentionally removed from a core or parent rock by percussion or pressure flaking. Usually bears diagnostic morphological attributed such as a bulb of percussion, ripples and a striking platform
Floodplain	Land adjacent to a river which is commonly covered by water during high flow periods
Forage	The seeking of food; food for animals
Frequency band	The range of frequencies at which electromagnetic signals are transmitted
Galactic noise	Electromagnetic radiation originating from outer space
Gamebirds	All species of grouse, partridge, prairie chickens, and pheasants
Geese	All species of geese and cormorants
Geotechnical	Relating to the study of the earth, particularly in regards to construction activities
Glaciofluvial	Related to streams formed from melting glaciers or to the deposits made by such streams
Groundscreen	A wire mesh on or near the ground which forms part of the antenna system
Grubbing	The removal of roots and other deleterious materials
Habitat	The place normally occupied by an organism
Harmonic	A frequency that is an integral multiple of the fundamental frequency

GLOSSARY

Definitions

Herbaceous	Relating to seed plants whose stems wither after each growth season
Histochemistry	The chemical make-up of cells and tissues
Histopathology	Tissue or cell changes resulting from disease
Holocene	The current geological epoch which began with the end of the last ice age, (ca. 10,000 years ago). See Pleistocene
Household	A group of people sharing a common residence
Hyperthermia	Elevated body temperature
In vivo	In the living body of an organism
In vitro	Outside the living body
Ionosphere	The part of the earth's atmosphere extending from about 25-250 miles above the surface that contains electrically charged particles
Lacustrine	Pertaining to, produced by, or formed in a lake
Leach fields	Man-made fill designed to remove solids from waste water by percolation
Lek	An area where birds assemble to carry on courtship behavior
Limestone	A sedimentary rock composed of calcium carbonate
Lithic flake scatters	Archeological sites consisting of rock debitage resulting from stone tool manufacture or use
Loess	A homogeneous, commonly nonstratified, silty deposit of eolian material
Lymphoblasts	A tissue that produces white blood cells
Meteorological	Pertaining to the science of weather forecasting
Microblade	A diminutive lithic blade generally made by pressure technique
Microwave	An electromagnetic wave with a frequency between 1,000 and 30,000 megahertz
Midden	A culturally produced deposit frequently comprised of refuse, organic material, and ash
Mixed forest	Containing both deciduous and coniferous trees

GLOSSARY

Definitions

Moraine	An accumulation of glacially transported materials having initial constructional topography formed at the terminus and lateral margins of the ice mass
Mound	A pile of earth covering an aboriginal grave
Mutagenesis	The occurrence or induction of genetic alterations in offspring
Native	A generalized reference to an individual or population whose ancestry may be traced to one of the indigenous American cultures
Nocturnal	Pertaining to nighttime, especially wildlife active at night
Omnivorous	Adapted to eating all types of foods, including both animals and plants
Outwash	Sediments carried by meltwater from a glacier and deposited beyond the terminal moraine
Overburden	Geologic materials covering other material of greater economic importance
Palustrine	Marsh-like
Passerines	All species of songbirds, woodpeckers, doves, cuckoos, nighthawks, and swifts
Patinated	Having a surface discolored by weathering
Permeability	The capacity of a rock to transmit fluid
Personal income	The sum of wages and salaries, proprietor's income, rental income, dividends, interest, and transfer payments less social security contributions.
pH	Symbol for the degree of acidity or alkalinity of water on a scale of 0-14 with 0 indicating maximum acidity, 7 representing neutral water, and 14 representing maximum alkalinity
Physiographic province	Area of similar geographic structure, history, and climate
Pleistocene	The earlier of the two epochs comprising the Quaternary Period, covering the period 1,800,000 to ca. 10,000 years ago, see Holocene
Porosity	The amount of void space within a rock
Prairie pothole region	A portion of the great plains of Canada and the U.S. characterized by numerous small depressions holding water

GLOSSARY

Definitions

Prehistoric	Refers to the period of time prior to recorded history
Productivity	The biologic value of an area or vegetation type, as wildlife habitat
Protohistoric	Refers to the period of time immediately preceding recorded history or initial contact with Euroamericans
Quaternary	Geological time period beginning ca. 1,800,000 years ago and continuing into the present time
Raptors	Birds of prey, such as eagles, hawks, and falcons
Riverine	Pertaining to a river or its environment
Sample survey	A survey covering only portions of a geographic area used to predict the likelihood of occurrence of a feature throughout the area.
Sandstone	A sedimentary rock composed of sand-size (.06-2.0mm) particles
Scatter	A distribution of cultural material such as fire-cracked rocks, pottery sherds, or lithic debitage
Seasonal wetland	Wetland that retains water only during the spring wet period
Sedimentation	The deposition of earth materials by natural processes
Semi-permanent wetland	A wetland that retains water during a substantial portion of the year
Shale	A sedimentary rock composed of clay sized (<.004 mm) particles
Sham-exposure	Exposing test animals to the motions of radiation exposure without the actual presence of radiation; used as a control in animal experiments
Siltstone	A sedimentary rock composed of silt-sized (.004-.06 mm) particles
Site	Locus of past human behavior
Sounder antennas	Antennas located at the CRS transmit site which will broadcast a signal in the 2-30 MHz band to determine atmospheric conditions as they relate to CRS signal propagation
Stratified	Formed or laying in beds or layers
Subspecies	A geographical or ecological subdivision of a species
Switch reflectors	Passive antennas that will reflect CRS signals to assist in system operation

GLOSSARY

Definitions

Temporary wetland	A wetland that retains water for only a short period during the spring wet season
Teratogenesis	The production of developmental abnormalities in fetuses
Terrace	A relatively flat, horizontal, or gently inclined surface formed by stream processes or slope movements
Thermoregulatory	Tending to maintain a constant body temperature
Threatened species	On the verge of becoming endangered
Till	A poorly- sorted sedimentary unit deposited directly from glacial ice
Tradition	Configuration of associated cultural traits which persist over a long temporal interval and over a broad geographic area
Tropospheric scatter radio	
Turbidity	The amount of suspended material carried in flowing waters
Varved	A laminated sedimentary bed in which individual laminations are deposited in one year's time
Waterbirds	All species of rails, coots, loons, grebes, herons, pelicans, gulls, terns, and kingfishers
Waterfowl	All species of duck, geese, swans, and cormorants
25-year 24-hour rainfall	The total 24-hour rainfall that occurs on average once every 25 years
100-year flood zone	The floodplain area that is covered by water on average once every 100 years

1. PURPOSE AND NEED FOR THE ACTION

1.1 OTH-B OBJECTIVE

The Over-the-Horizon Backscatter (OTH-B) radar is a surveillance and tracking radar system that the U.S. Air Force plans to construct and operate at four locations in the United States. The East Coast Radar System (ECRS) in Maine is undergoing operational testing. Construction of the West Coast Radar System (WCRS) in California, Oregon, and Idaho is complete. The contract award for the Alaskan Radar System (ARS) is expected in 1990. The Central Radar System (CRS) is examined in this Environmental Impact Statement (EIS). The objective of the four OTH-B radar systems is to detect, track, and give early warning of aircraft approaching North America from the northwest, west, south, east, and northeast. The existing North Warning System that stretches across northern Canada monitors the northern approaches to North America.

The OTH-B system can detect aircraft flying at any altitude at distances ranging from 500 to 1,800 nautical miles (nmi) (575 to 2,070 statute miles) by reflecting electromagnetic energy off the ionosphere. The range of conventional microwave radars is limited to line-of-sight coverage, which extends for only a few hundred miles because of the earth's curvature. The greater range of the OTH-B system considerably increases the warning time, particularly for high-speed aircraft flying at low altitudes.

1.2 PURPOSE AND NEED

The OTH-B program is designed to provide early detection of hostile aircraft approaching North America. The Congress of the United States has determined that this system is necessary

for the defense of the United States and for that reason has authorized construction of the East Coast, West Coast, and Alaskan Radar Systems. Congress has also authorized advance planning of the CRS, as well as environmental studies including this EIS. The CRS will complete coverage of the approaches to North America by providing long-range surveillance of areas along the Pacific and Atlantic near-shore areas and the southern flank of the continent.

1.3 OTHER OTH-B SYSTEMS

The CRS would consist of four sectors, each covering a 60° arc, for a total coverage arc of 240° over the western, southwestern, southeastern, and eastern approaches to North America, including the Gulf of Mexico, the land area of Mexico, and the Pacific Ocean west and south of Mexico. The CRS would also cover near-shore areas along both the eastern and western coasts of North America that are not covered by the ECRS and WCRS because the OTH-B system functions only at a distance greater than 500 nmi from the receive antennas. Thus, CRS would complete coverage of those areas, overlapping the surveillance areas of the ECRS and WCRS (see Figure 1.3.1).

1.4 PREVIOUS ENVIRONMENTAL STUDIES

1.4.1 Site Selection Process

The following requirements were applied to determine the general location for CRS:

- Cover the near-shore Atlantic and Pacific areas.
- Overlap with the North Warning System in the northeast.
- Complete the arc of continuous OTH-B coverage across the southern approaches to North America.

SOURCE: U.S. Air Force

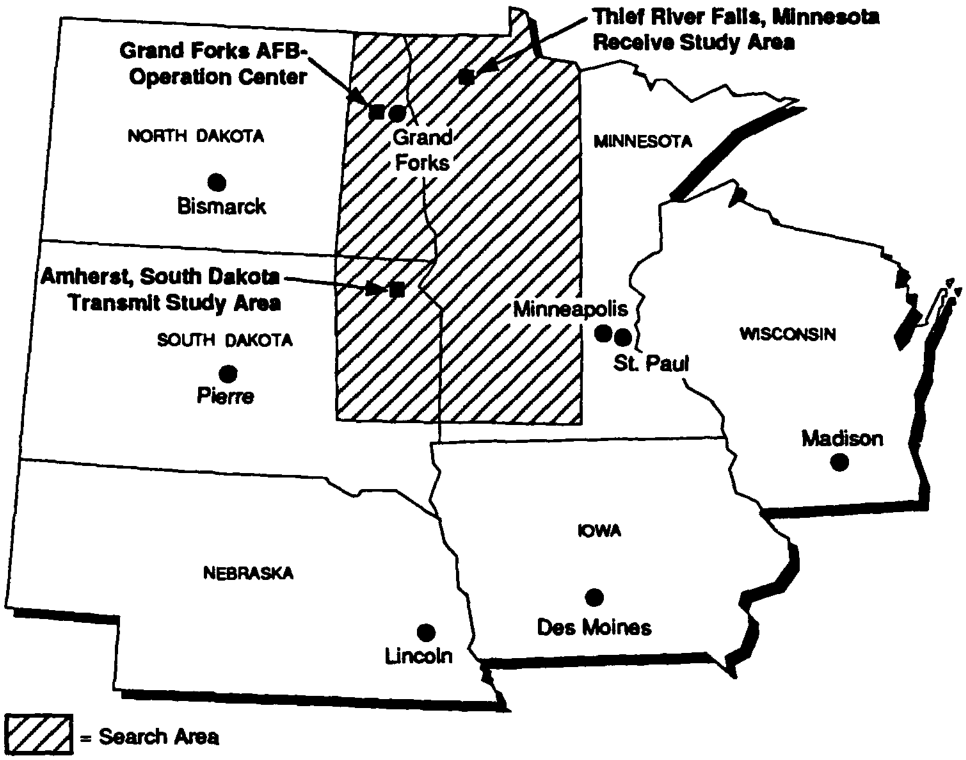
FIGURE 1.3.1 COVERAGE AREA FOR OTH-B RADAR SYSTEMS

Because of the OTH-B minimum and maximum ranges, the area where CRS could be located to meet the requirements listed above is limited to portions of the upper Midwest (see Figure 1.4.1 and also Section 2.2.1). Within that region, Grand Forks Air Force Base (AFB), North Dakota, was determined to be the only suitable location for the CRS Operations Center, which must be located on a military base. Other requirements for the transmit and receive sites include acceptable amounts of relatively flat land for the four antennas and minimum distance from railroads, population centers, and major airways. Based on those criteria, nine study areas ranging in approximate size from 12,000-122,000 acres were identified.

1.4.2 1987 EIS and ROD

The nine alternative study areas were investigated in a Draft EIS that the Air Force prepared in 1986 and in a Final EIS prepared in 1987. On September 8, 1988, the Air Force released a Record of Decision (ROD) for CRS stating that the preferred locations were the Amherst, South Dakota, study area for the transmit antennas and the Thief River Falls, Minnesota, study area for the receive antennas. The ROD also stated that construction and operation of the operations center at Grand Forks AFB would not result in significant adverse environmental impacts, but required further environmental assessment of possible site-specific effects at the proposed transmit and receive sites.

Because the Amherst study area is approximately 150 mi^2 and the Thief River Falls study area is approximately 172 mi^2, or about roughly 40 times larger than the land actually required for CRS facilities, highly detailed investigations of those study areas were not practical. Therefore, two concentrated study areas (CSA) ranging in size up to 20 mi^2 were selected at each study area, and preliminary site layouts were prepared for each CSA. This environmental document examines possible impacts from each of the two alternate preliminary site layouts for the transmit and receive facilities at the same level of detail. As determined by the 1988 ROD,



SOURCE: U.S. Air Force

FIGURE 1.4.1 SEARCH AREA FOR CRS TRANSMIT AND RECEIVE SITES

no significant environmental effects will result from construction and operation of the CRS operations center at Grand Forks AFB, and that facility is not examined in this EIS.

1.4.3 EIS Scoping

As required by the National Environmental Policy Act and Air Force Regulation 19-2, the Air Force held meetings during September and October 1989 and February 1990 to determine the scope of issues that would be addressed in this EIS. The scoping meetings were held in Minnesota and South Dakota and the public and representatives from local, state and federal governmental agencies were invited. The results of the scoping process are given in two reports - Report on the EIS Scoping Process for the U.S. Air Force OTH-B Central Radar System (SRI International, 1989) and Addendum, Scoping Summary Report for Over-the-Horizon Backscatter Central Radar System (SRI International, 1990A).

A large number of people attended the scoping meetings and commented on the proposed action. Many questions concerned the description of the CRS, the selection process for the alternative sites, the environmental review process, and the need for the action. Sections 1 and 2 of the EIS responds to those comments. Many comments concerning the environmental effects of the CRS were received. Concern was expressed about filling of wetlands, vegetation removal, the potential for bird collisions with antennas, loss of wildlife habitat, removal of farmland from production, use of possible water pollutants at the CRS site, interference with radio and television reception, possible hazards from human exposure to electromagnetic signals, and reduction in property-tax revenues to school districts. Those issues are analyzed in section 4 of this EIS. The EIS follows a systemic interdisciplinary approach to analyze possible environmental effects. The emphasis of the analysis is placed on impact areas identified as significant public and agency concerns during the scoping process.

2. PROPOSED ACTION AND ALTERNATIVES

2.1 PROPOSED ACTION

The CRS will consist of three parts: an operations center, a transmit site, and a receive site. Each of the three parts is necessary for operation of the complete system. The operations center processes data and controls overall functioning of the system. The transmit site produces electromagnetic signals and the receive site detects the signals that reflect off targets. This section describes each component of the CRS and alternatives to the OTH-B system.

2.1.1 Operations Center–Grand Forks AFB, North Dakota

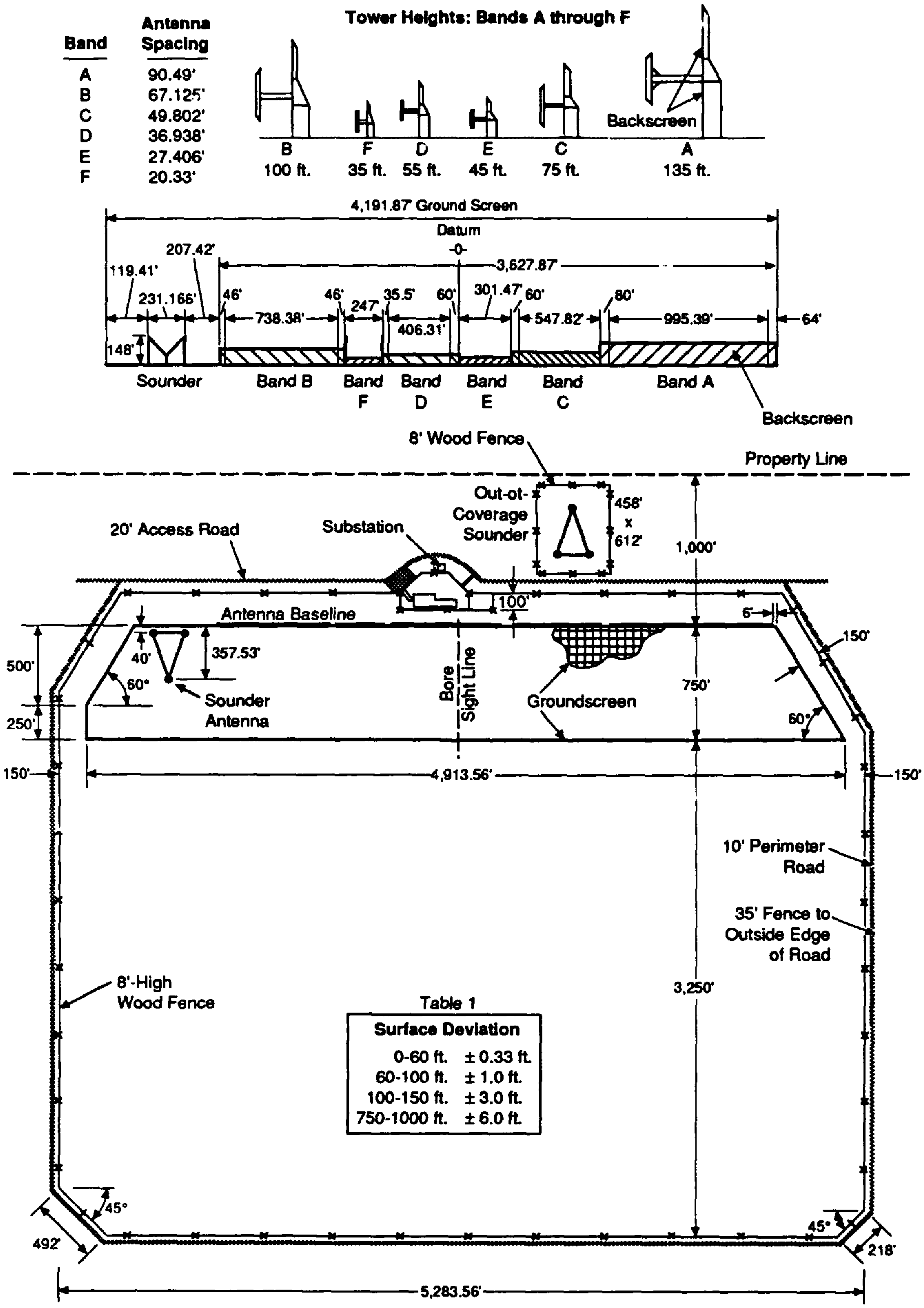
The CRS operations center (the Center) is proposed for Grand Forks Air Force Base (AFB) in eastern North Dakota, approximately 30 mi southwest of the CRS receive study area and approximately 150 mi north of the CRS transmit study area. The computers, operator displays, and communications equipment of the Center will be housed in an operations building having about 48,000 ft^2 of floor space. The building will be surrounded by a 60-ft-wide security perimeter. The center staff will number approximately 390, most of whom will be Air Force personnel. Microwave links, tropospheric scatter radio, and/or satellite links will allow communications between the Center and the transmit and receive facilities. The Air Force ROD of September 8, 1988, determined that no significant adverse environmental impacts will result from construction and operation of the Center at Grand Forks AFB. There have been no changes in the proposed siting, design or operation of the Center which would significantly change the environmental analysis included in the 1987 EIS. Thus the finding of no significant adverse environmental impact is still valid.

2.1.2 Transmit Site

2.1.2.1 Structures

The principal structures at the transmit site will be four 5,000-ft-long transmit and sounder antennas (see Figure 2.1.1). Each antenna will have a backscreen composed of wire mesh and structural steel ranging in height from 35-135 ft and a groundscreen at grade extending 750 feet in front of the antenna. The backscreen will include modifications developed for the ARS that provide larger openings to reduce the potential for bird collisions. The antenna will be composed of six subarrays, each containing 12 radiating elements mounted on vertical steel towers erected on concrete foundations. The subarrays for Bands C, D, E, and F (corresponding to specific frequency bands of the electromagnetic spectrum) would have a backscreen composed of wire mesh with 22-in square openings rising to a height of 75 ft. The backscreen will rise to 135 ft above the ground for Band A and to 100 ft for Band B. Above 75 ft in height, the backscreen for Bands A and B will consist of 2-ft square wire columns forming a vertical grid with 8-ft square openings. The wire columns will reduce the potential for bird collisions because they will present larger openings than the wire mesh backscreen (8 ft vs. 22 in.) and will also be more visible. A groundscreen composed of wire mesh will extend on the ground 750 ft in front of each antenna. The four antennas will be oriented to transmit toward the east, southeast, southwest, and west (the transmit direction is perpendicular to the long axis of the antenna). Figure 2.1.2 shows an aerial view of one ECRS transmit sector. The CRS transmit sectors will be similar.

Two sounder antennas will be located adjacent to the transmit antennas at each sector. One sounder will be located at one end of the transmit antenna and is included in the total antenna length of about 5,000-ft. The other sounder antenna will be located behind the transmit antenna and adjacent to the equipment building. Each sounder antenna will consist of two 150-ft-high vertical truss towers with radiating elements connecting to a third 50-ft-high monopole. The



SOURCE: U.S. Air Force

FIGURE 2.1.1 TYPICAL PLAN FOR OTH-B CRS TRANSMIT SECTOR

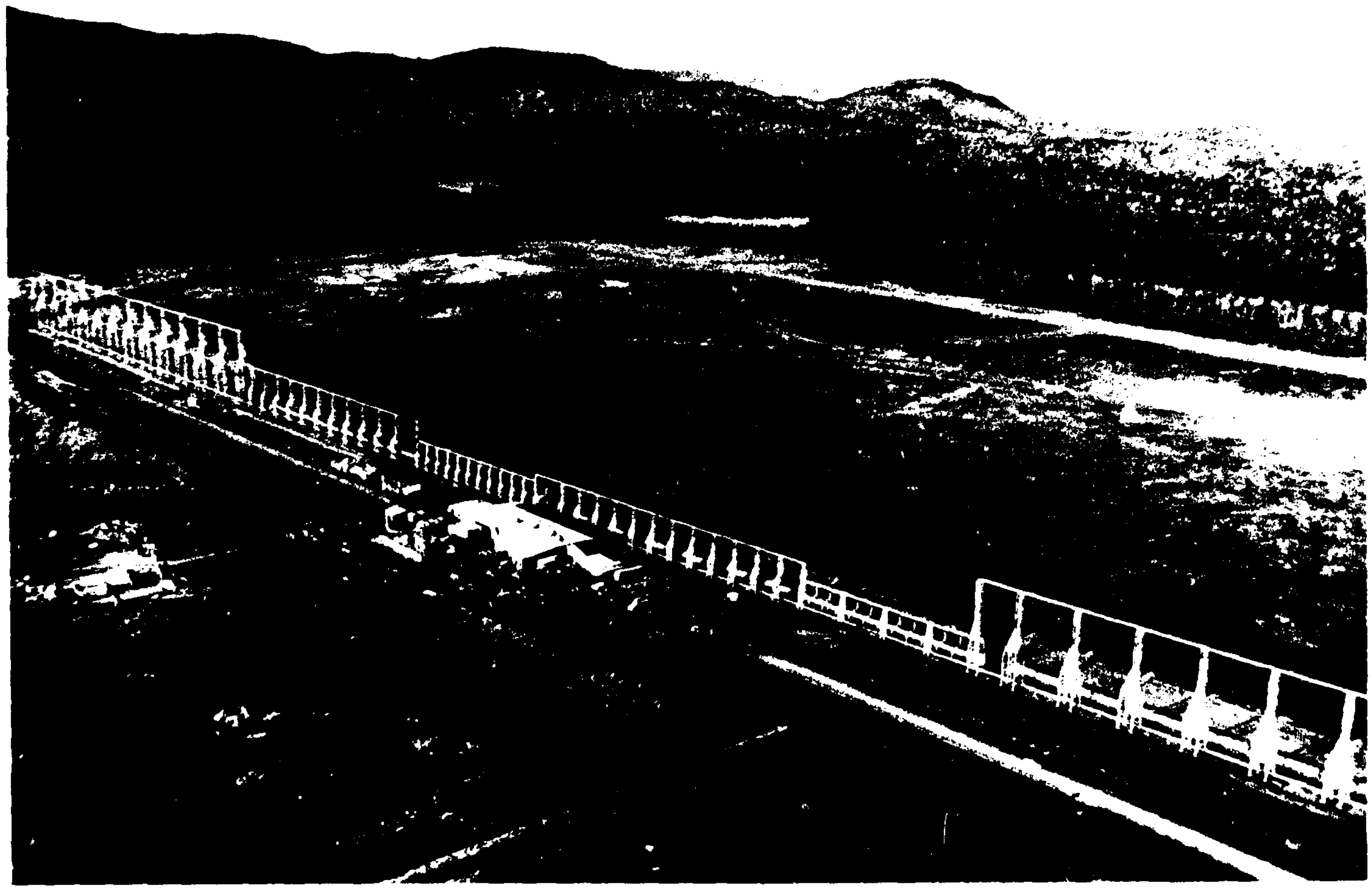
antennas will transmit and receive a signal that sweeps frequencies from 2-30 MHz to identify atmospheric conditions and determine the optimal operational band for the CRS.

Equipment necessary to operate the transmit antenna will be housed in a one-story 15,000-ft^2 metal building located behind each antenna, except at the staffed sector where the operations staff would be based. Either the southwest or southeast sector will be staffed. The equipment building for the staffed sector will have a floor area of 17,000 ft^2 The foundation would probably be slab on grade. The staffed sector equipment building will also have administrative offices, a first aid dispensary, toilets, a briefing room, a kitchenette, and storage for administrative and housekeeping supplies.

Each transmit building will have a storage tank for diesel fuel, emergency generators, water storage tanks, vehicle parking spaces, and a fenced enclosure for a trash dumpster. The staffed sector will have a garage for two vehicles. Security flood lighting will be installed at all facilities and along the antenna field, for use only during an emergency. An 8-ft-high wooden fence will surround the antenna and equipment building at each sector.

2.1.2.2 Antenna Operations

The four transmit antennas will project an electromagnetic beam with a frequency between 5-28 MHz outward from the antenna face. The continuous wave (CW) beam will be electronically steered by varying the phase of the radiofrequency power delivered to the 12 radiating elements within the operating band to cover the area 30° to either side of the antenna boresight, which is perpendicular to the long axis of the antenna. The wavelength of the beam will vary from 10.7-60 meters (m).



SOURCE: U.S. Air Force

FIGURE 2.1.2 EAST COAST RADAR SYSTEM TRANSMIT ANTENNA AND RELATED FACILITIES

2.1.2.3 Roads

The road network serving the CRS transmit facilities will be used for access to the facilities and to conduct security patrols of the exclusion area boundary. The perimeter roads, gravel with a single 10-ft-wide travel lane, will be outside the exclusion fence. The access road to the transmit site will have two 10-ft-wide lanes with 4-ft shoulders. Depending on the precise siting of the antennas, the exclusion areas may adjoin or overlap in part, reducing the length of necessary perimeter road. If each antenna were to have a distinct perimeter road surrounding it, the total length of all roads for the four transmit sectors would be about 20 mi. Although existing roads could serve as part of the road network, most roads would probably be newly constructed. Approximately 1-2 mi of access road would also be constructed, depending on which alternative site is selected.

Gravel-surfaced parking lots will be built at each sector. The area of each will be 4,500 ft^2, except at the staffed sector, which will have a parking area of 11,500 ft^2.

2.1.2.4 Utilities

Power Supply - Each transmit sector will have a peak electrical demand of 3,600 kilowatts (kW). Therefore, total peak electrical load for all four sectors will be 14,400 kW. At completion, annual power requirements for the four transmit sectors throughout the system's operational life will total about 126,536,000 kilowatt-hours (kWh). The electric power will be used primarily to power the transmit elements.

Electric power will be delivered to the transmit site by two new, dedicated 115-kilovolt (kV) transmission lines to be constructed for CRS. The Air Force plans to have the Western Area Power Administration (WAPA) of the U.S. Department of Energy (DOE) construct transmission lines between existing substations at Forman, North Dakota, and at Groton, South Dakota, and the chosen transmit site. Each line will be able to supply the full electrical needs of the transmit

sectors, thereby providing a back-up route in case one line fails. The Forman and Groton substations will be expanded to accommodate the new transmission lines (Harris, 1990). One substation will be constructed at the transmit site to reduce voltages from 115 kV to 12.47 kV for distribution to each antenna sector.

The Forman and Groton substation expansions would require up to 11,000 ft^2 of land at each location. Equipment to be installed includes 115-kV circuit breakers, high-voltage switches, steel support bus structures, and 115-kV metering equipment on concrete footings. An 8-ft high chain-link fence will be built around the expansion area. The substation at the transmit site will consist of six 115-kV circuit breakers, two 115-kV/12.47-kV transformers, a control building, 115-kV switches, steel bus and takeoff structures mounted on concrete footings, and an 8-ft-high chain link fence.

The transmission lines connecting the substations at Forman, North Dakota, and Groton, South Dakota, to the substation at the CRS transmit site will be 115-kV lines. The likely transmission line structure would be a wooden H-frame consisting of two 55-ft-high wooden poles connected by a wooden cross-piece. Three transmission wires (conductors) would be connected to insulators mounted on the crosspiece. One or more wires at the top of the structure would provide lightning protection. Alternatively, steel or concrete monopoles may be used. The monopoles would range up to 95 ft above the ground and have lateral crossarms with insulators to support conductors. Structures will be located within an 80- to 150-ft-wide right-of-way (ROW) to be acquired by WAPA. The H-frames would be spaced at 700-ft intervals and the monopoles at 1,000-ft intervals (7.5 to 5.3 structures per mile of transmission line). Transmission line structures will be inserted into preaugered holes, grouted, and backfilled with soil, temporarily disturbing an area of about 300 ft^2 during construction.

When necessary, trees along the transmission line route will be removed to provide access to the line and clearance for conductors. For access, a 15-ft-wide path would be cleared. However, trees are sparse and most structure sites should be accessible without tree removal. Trees will be

removed when necessary to provide 25 ft of clearance between the conductor at maximum sag and trees underneath for a distance of 28 ft to each side of the transmission-line centerline. Beyond 28 ft from the centerline, allowable tree height rises 1 ft for each foot in lateral distance to the edge of the ROW. Trees within the ROW that, upon falling, will come within 10 feet of structures or conductors, will be removed. (WAPA, 1983)

New land and land rights will be required for the transmission line. Permanent easements will be acquired for transmission line and access road ROWs. The ROW could vary in width between 80 and 150 ft, unless the powerline is adjacent to an existing powerline ROW, in which case the ROW width could be less than 80 ft. Assuming a transmission line ROW length of 70 mi and a maximum width of 150 ft, about 1,273 acres of permanent easement will be acquired. About one-quarter acre of land owned by WAPA adjacent to the existing Forman and Groton substations will be used for expansion of the two substations. All land rights for the powerline ROW will be acquired in accordance with the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (Public Law 91-646) and other applicable laws and regulations governing federal acquisition of property rights. Landowners will be paid fair market value for acquired property rights. Every effort will be made to acquire these rights by direct purchase. However, if the necessary rights cannot be acquired through negotiation, federal eminent domain proceedings would be instituted to obtain these rights. All agreements will provide for the payment of damages caused by the construction, operation and maintenance of the line. Land for substation sites will be purchased. (WAPA, 1983)

Normal farming activities will be permitted within the ROW if they do not interfere with transmission line operation and maintenance. The design of the line will allow safe operation of 16-ft-tall farm machinery beneath conductors. WAPA will perform routine aerial and ground inspection surveys of the lines several times per year. (WAPA, 1983)

Although WAPA will construct and maintain transmission lines to serve the CRS transmit sectors, the actual power supplier will be determined through competitive bids. The selected

company will enter a long-term contract with the Air Force to provide electricity that will be transmitted (wheeled) via the WAPA grid, including the project transmission lines, to the site. There are many potential power suppliers in the area and many of them are members of the Mid-Continent Power Pool. The selected power company is expected to have ample generating capacity or access to power supplies to serve the project. (ARC Professional Service Group, 1989)

To provide standby power for electrical needs, one 175-kW diesel generator will be installed at each transmit sector. That generator will supply electricity for lighting, communications, and fire protection, but will be unable to power the transmit antennas. An underground storage tank for diesel fuel with 6,000-gal capacity will be installed near each equipment building.

Communications—The transmit facilities will require communications systems to relay classified and unclassified information to the operations center. Telephone lines for unclassified use and secure lines for classified use will be installed. Data handling will require an auxiliary communications system with the capability to handle both unclassified and classified material. The transmit sectors will be connected to the operations center by a microwave, tropospheric scatter radio, satellite communications system, or a combination of those systems. In the case of a microwave link, a parabolic dish antenna with a diameter of up to 7 m would be installed on a 100-ft-high tower on site. One or more repeaters, if necessary, would be mounted on similar towers between the transmit site and the operations center. The tropospheric scatter radio or satellite systems would require a parabolic dish antenna mounted on a 60-ft tower; no off-site repeaters would be required. All towers are expected to be located within the perimeter fence near the equipment building. The design of the back-up communications system, including locations of off-site microwave repeaters if needed, is undetermined at this point.

Water and Wastewater—A permanent water well will be installed at each sector for use during construction and operations. The expected depths for those wells are 150-300 ft for Tx-N and 900-1,500 ft for Tx-S. Peak water consumption is estimated at 50,000-100,000 gallons per

day (gpd) during construction and 3,000 gpd during operation. An above-ground storage tank (22 ft tall and 25 ft in diameter) with a capacity of 75,000 gal will be installed on site for fire suppression.

Domestic wastewater generated will be disposed of by means of septic tanks and leach fields or a sanitary holding tank.

2.1.2.5 Personnel

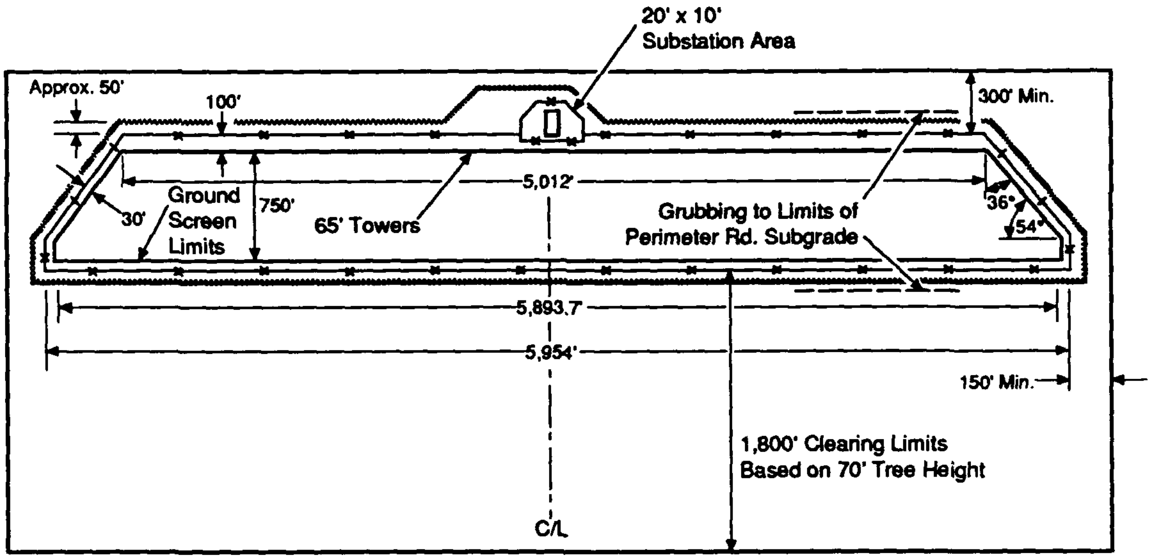
During construction, an average of approximately 60 workers will be employed at each transmit sector. During some periods, two sectors will be simultaneously under construction and average employment will be 120. Maximum construction employment at the transmit sites will be 220. Construction of the site substation and the expansions of the Groton and Forman substations will require an additional 25 employees for up to 8 months (WAPA, 1983). Construction of the power lines will require 25-30 employees for up to 24 months.

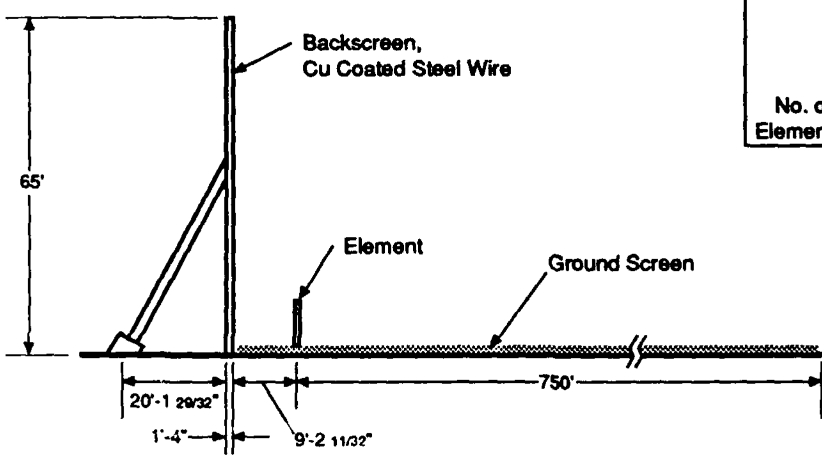
The CRS transmit facility will have a permanent staff of about 25 workers. Of these workers, two to three will be military personnel and the remainder will be civilians. An estimated five to six employees will work at the buildings behind each antenna during each 8-hr shift. The staff will conduct security patrols on the perimeter roads.

2.1.3 Receive Site

2.1.3.1 Structures

As will be the case at the transmit site, the largest structures at the receive site will be four antennas, one each at the western, southwestern, eastern, and southeastern sectors (see Figure 2.1.3). Each receive antenna would be composed of 19-ft-tall receiving elements with a backscreen 5,012 ft long and 65 ft tall throughout its length. The wire-mesh backscreen will have 10-in by 20-in openings below a height of 35 ft above the ground. Above 35 ft in height,





Frequency:	5 to 28 MHz
Low Band:	5 to 9.79 MHz
Mid Band:	9.79 to 15 MHz
High Band:	15 to 28 MHz
No. of Elements:	246
Elements Spacing:	20 feet

Table 1

Surface Deviation	
0-60 ft.	± 0.33 ft.
60-100 ft.	± 1.0 ft.
100-150 ft.	± 3.0 ft.
750-1000 ft.	± 6.0 ft.

SOURCE: U.S. Air Force

FIGURE 2.1.3 TYPICAL PLAN FOR OTH-B CRS RECEIVE SECTOR

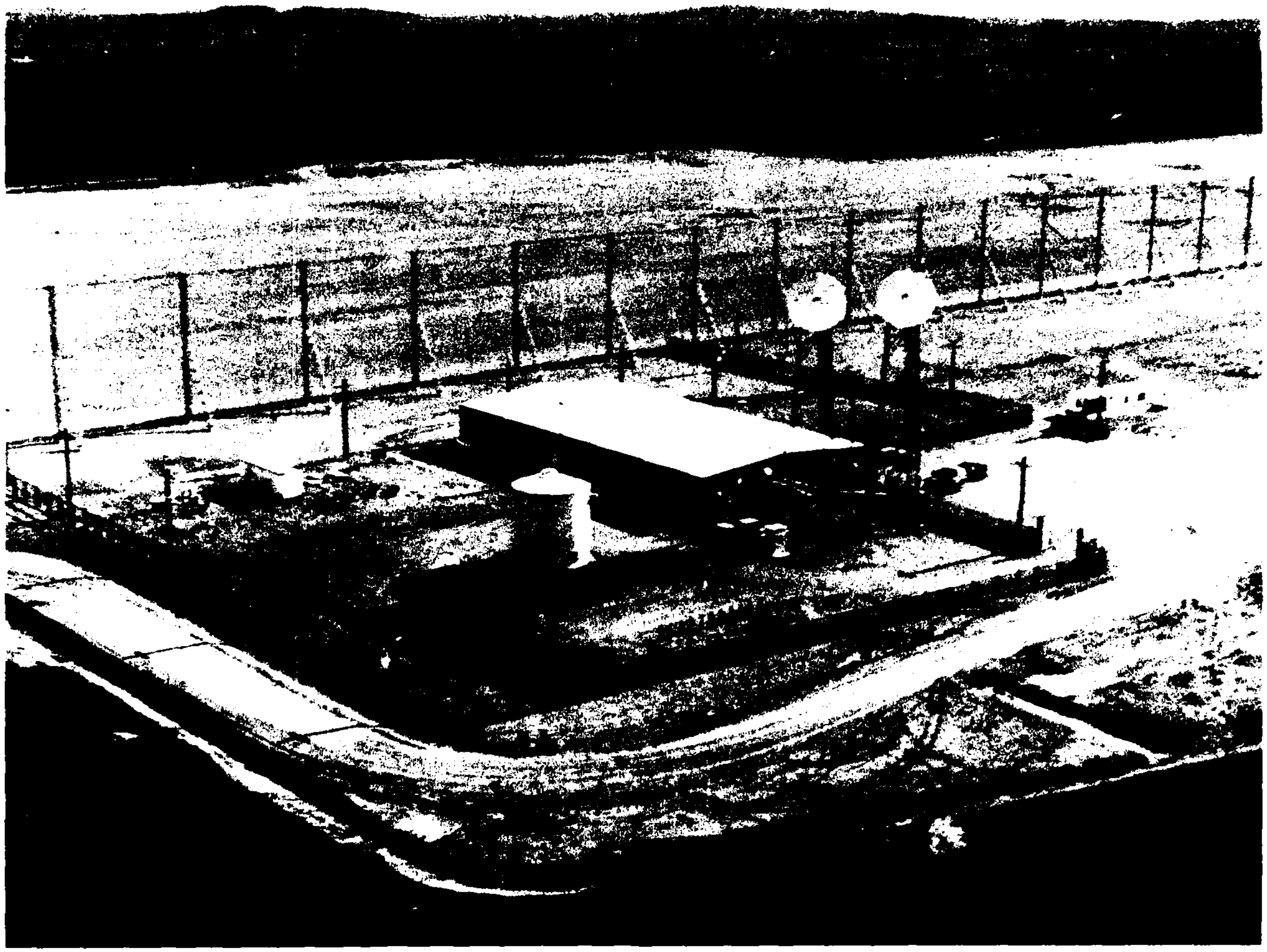
the backscreen will include modifications developed for the ARS antennas, consisting of vertical 2-ft by 2-ft wire columns spaced at 8-ft intervals to increase the probability that birds will pass through the backscreen without harm. A truss connecting the vertical wire columns will span the crest of the backscreen. A ground screen laid on a gravel base will extend on the surface of the ground for 750 ft in front of the antenna. The receive antennas will not radiate electromagnetic energy. Figure 2.1.4 shows an aerial view of one ECRS receive sector. The CRS receive sectors will be similar.

Equipment to operate each antenna will be housed in a one-story metal building located behind each antenna and having a total floor area of 4,200 ft^2. Either the southwest or the southeast sector will be staffed. At the staffed sector, an 8,000-ft^2 equipment building, a two-vehicle garage, and a storage shed will be built. Facilities will be the same as described for the transmit site in Section 2.1.2.1. The buildings will be accessible via roads connecting to the local road network. An 8-ft-high wooden fence will surround the antenna and equipment building at each sector.

Foundation design for the antennas and equipment buildings will depend on soil conditions at the chosen site.

2.1.3.2 Antenna Operations

The receive antennas will not radiate electromagnetic energy as the transmit antennas will, Rather, they will receive energy reflected by targets within the surveillance area. The antennas will operate 24 hr per day to provide continuous surveillance. The data generated by antenna operation will be transmitted to the operations center for analysis and interpretation.



SOURCE: U.S. Air Force

FIGURE 2.1.4 EAST COAST RADAR SYSTEM RECEIVE ANTENNA AND ASSOCIATED FACILITIES

2.1.3.3 Roads

An access road with two 10-ft-wide gravel lanes and 4-ft shoulders will be constructed. A 3-mi-long perimeter road, consisting of a single 10-ft-wide gravel-surfaced lane, will surround each antenna outside the perimeter exclusion fence. Some existing roads may be used for access and security patrols, but most roads will probably be newly constructed for CRS. A gravel-surfaced 4,500 ft^2 parking area will be constructed at each sector, except that the parking area at the staffed sector will be 11,500 ft^2.

2.1.3.4 Utilities

Power Supply—Each receive sector will have a peak electrical demand of 500 kW. Therefore, the total peak electrical demand for the four sectors will be 2,000 kW. At completion, annual power requirements throughout the system's operational life will total about 17,520,000 kWh. (ARC Professional Services Group, 1989)

The power supplier would depend on which site is chosen for the receive sectors. If the eastern site in Pennington County is selected, Red Lake Electric Cooperative will serve the project. If the western site in Polk County is chosen, PKM Electric Cooperative will serve the project. Both cooperatives are part of and purchase wholesale power from the Minnkota Power Cooperative. The project demand would represent a small incremental increase in power demand from Minnkota, and no new generation capacity would be required. (ARC Professional Services Group, 1989)

Power transmission lines serving the receive sectors will be 7.2 or 12.47-kV lines, which are similar to existing distribution lines in the vicinity. If aerial, the lines will be mounted on 35-45-ft-high single wooden poles spaced 270 ft apart. A subsurface line would be installed at a depth of 40-48 in. in a trench excavated for the lines and then refilled. Underground powerlines will require installation of a junction box measuring 5 ft by 3 ft by 2 ft at each mile section

boundary. A transformer and secondary switchgear pad will be constructed on site to transform the power to lower voltage. Within 0.5 mi of the receive antennas, the power transmission line will be placed underground to prevent degradation of antenna performance.

Powerline construction will necessitate preparation of a Borrower's Environmental Report (BER) as required by the Rural Electrification Administration and acquisition of a ROW by the power cooperative. The BER will further examine possible environmental effects of the project. ROW acquisition and line construction procedures will be similar to those described above for the transmit-site power transmission lines. If underground lines are installed, vegetation along the trenching route will be removed, but "danger trees" will not have to be removed as they would be for aerial lines.

To provide emergency power, two 300-kW diesel generators will be installed at each receive sector. The generators will be capable of maintaining full operational capability at each receive sector. One underground 10,000-gal storage tank for diesel fuel will be installed at each sector.

Communications—The receive site will use commercial telephone service for unclassified communications, a classified telephone system for secure communications, and unclassified and classified data-handling systems. As for the transmit sectors (see Section 2.1.2.4), a microwave link, tropospheric scatter radio, satellite system, or a combination of those systems would connect the receive sectors to the operations center. Off-site repeaters would probably not be required for a microwave link.

Water and Wastewater—The water and wastewater facilities at the receive site will be the same as for the transmit site (see Section 2.1.2.4). Water consumption will be about 50,000-100,000 gpd during construction and 3,000 gpd during operation. A well will be installed at each sector; the depth is expected to be 150-300 ft. An above-ground 75,000-gal water storage tank (25 ft in diameter and 22 ft high) will be installed near the equipment building at each sector for fire suppression.

About 3,000 gpd wastewater will be generated by domestic uses. Disposal of the wastewater will be by septic tank and leach field or a sanitary holding tank.

2.1.3.5 Personnel

Construction employment for the receive antennas will be the same as for the transmit antennas, averaging 60 employees per sector (total average employment of 120 employees for two sectors simultaneously under construction) with maximum employment of about 220. The powerline will be constructed by local crews from the electric cooperative (estimated at 10 to 20 workers total) and would take less than one month.

Operational staffing requirements for the receive site will be the same as those for the transmit site. An estimated total of 25 employees, including 2 to 3 military personnel, will work in shifts of 5 to 6 people.

2.1.4 Schedule

2.1.4.1 Environmental Impact Analysis Process

The Draft EIS will be distributed to appropriate agencies and interested members of the public, who will have 45 days to submit written comments to the Air Force. During the public and agency review period, public hearings will be held in the vicinity of the transmit and receive sites to receive oral and written comments on the EIS. After the public and agency review period closes, a Final EIS containing responses to all substantive comments on the Draft EIS will be prepared and distributed to responsible agencies and interested members of the public. The release of the Final EIS will be announced in the Federal Register. After a 30-day waiting period, the Air Force may issue a ROD deciding which of the two South Dakota CSAs will be used for the CRS transmit site and which of the two Minnesota CSAs will be used for the CRS receive site.

2.1.4.2 Land and Permit Acquisition

The Air Force is willing to acquire land for CRS by either purchase or lease. Although purchase is the typical method used to acquire land, leasing will be considered to mitigate adverse socioeconomic effects of the project. Lease terms would be negotiated between the landowner and the U.S. Army Corps of Engineers. A third option is the use of easements, by which the Air Force would purchase a right to use the land for a specified period.

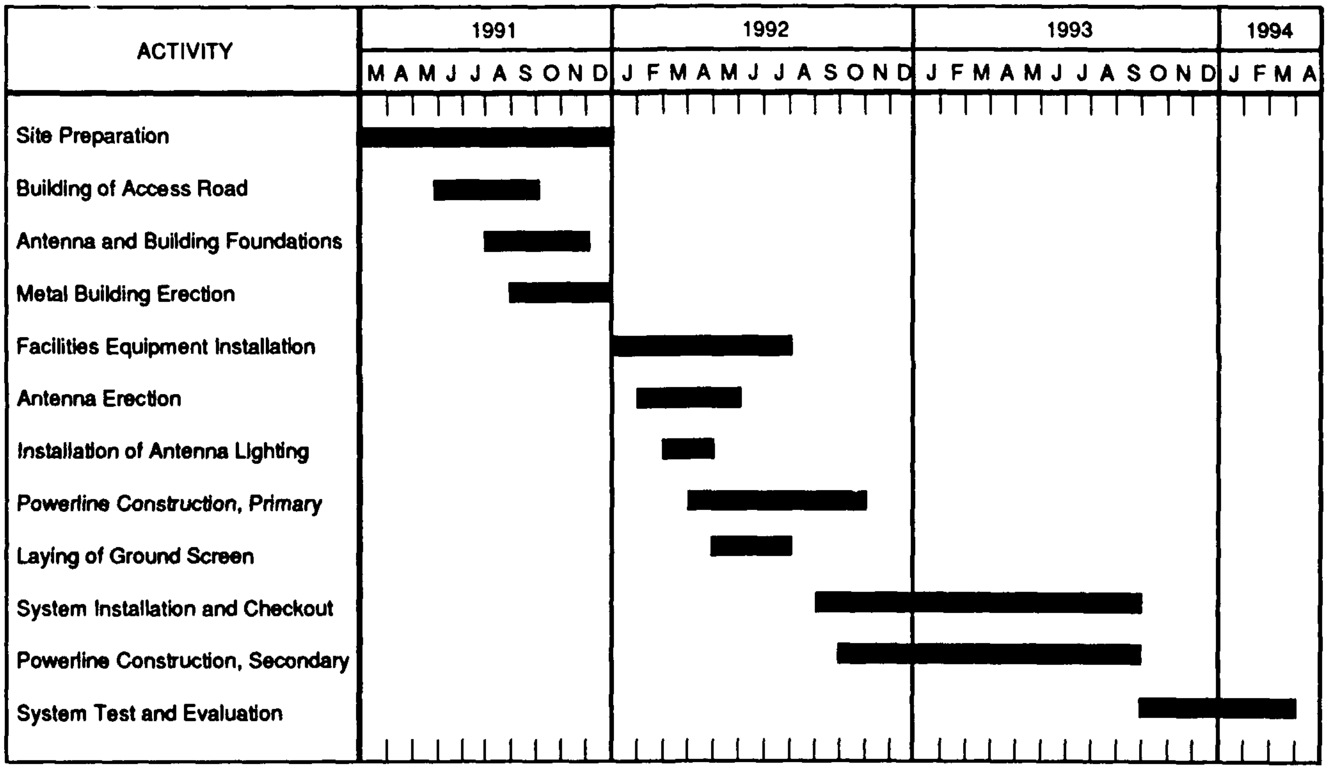
Permits from several federal agencies, as outlined in Section 2.4 of this EIS, will be required for CRS. The Air Force will submit permit applications during the period between EIS completion and the start of CRS construction.

2.1.4.3 Contractor Selection

The Air Force will not acquire land for CRS until the ROD has been completed. Thus, land acquisition will occur during late 1990 and early 1991 and will be completed in 1991. The Air Force plans to award the prime system contract by mid-1991.

2.1.4.4 Construction

The construction of CRS will begin with the southwest and southeast antennas at the transmit and receive sites in 1991. Figure 2.1.5 shows the proposed schedule for construction and testing of CRS facilities, including the power transmission lines. Those facilities are expected to be ready for preoperational testing by 1993, and actual operation would occur in 1994. As determined by the availability of funds, construction of the east and west sectors of the transmit and receive facilities would start at least one and possibly more years after the first two



* *Construction of the third and fourth sectors would begin roughly two to three years after the start of construction for the initial two sectors.*
The duration and sequence of construction activities would be the same for the initial and final sectors.
SOURCE: *SRI International*

FIGURE 2.1.5 CONSTRUCTION AND TESTING SCHEDULE FOR INITIAL TWO SECTORS OF CRS*

sectors. Thus, the construction periods for the east and west sectors could overlap that for the earlier two sectors.

2.1.4.5 Operation

The southwest and southeast sectors of CRS are scheduled for operation in 1994. The east and west sectors will join the system at an undetermined later date. The complete system is expected to operate for 20 or more years. The date for initial operation of all four sectors is unknown at this time.

2.1.4.6 Decommissioning

At the end of its operational life, which is expected to be 20 or more years, CRS will be decommissioned. The disposition of the land will depend on the laws and regulations applicable at that time. Land that was purchased would be examined under the Department of Defense (DoD) Installation Restoration Program to ensure that no contamination exists and then turned over to the General Services Administration (GSA) to determine if the federal government needs the land for other uses. If another federal government use is identified, that use must be analyzed for potential environmental effects under the National Environmental Policy Act (NEPA). Should no federal agencies have a need for the land, it would be offered to State governments, local governments, and the public, in that order, as surplus federal land. Leased land would be returned to the lessor under the terms negotiated between the lessor and the Air Force. Those terms could include removal of all property improvements, such as concrete foundations.

2.1.5 Permit Requirements

Table 2.1.1 lists federal permits that may be required for operation and construction of OTH-B CRS.

Table 2.1.1
PERMITS POTENTIALLY REQUIRED FOR THE CONSTRUCTION AND OPERATION OF CRS

Agency	Permit/Approval Authority
Advisory Council on Historic Preservation	Section 106 (review process for compliance with National Historic Preservation Act)
Army Corps of Engineers	Section 404/10 (wetlands dredge/fill permit)
South Dakota Dept. of Water and Natural Resources (DWNR), Minnesota Pollution Control Agency (PCA), Environmental Protection Agency (EPA)	National Pollutant Discharge Elimination System (NPDES) permit for wastewater disposal (federal permit authority delegated to states)
Environmental Protection Agency	Spill Prevention, Containment and Countermeasure Plans
U.S. Fish and Wildlife Service	Section 7 consultation for compliance with Endangered Species Act
Minnesota Dept. of Natural Resources (DNR), EPA	Water Quality Certification Section 401 (federal permit delegated to State of Minnesota)
Federal Aviation Administration (FAA)	Notice of Proposed Construction or Alteration
EPA	Notification for Underground Storage Tanks

Source: Metcalf & Eddy/Holmes & Narver, 1990A

2.1.6 Air Force Preferred Sites

2.1.6.1 Transmit Site

The U.S. Army Corps of Engineers (COE), as land acquisition agents for the Air Force, has contacted all the owners of land at each alternative CSA. The landowners at Tx-N have indicated a greater willingness to sell or lease land to the Air Force for CRS than those at Tx-S. Hydrological impacts and the complexity and cost of mitigating those impacts would also be greater at Tx-S. For example, the volume of flood-storage capacity which would be eliminated during CRS site preparation would be 1,700 acre-feet at Tx-S and 670 acre-feet at Tx-N. Construction of the CRS transmit facilities would also increase runoff rates at Tx-S but not at Tx-N. Thus, to minimize the need to acquire land from unwilling owners and reduce both socioeconomic and hydrological impacts, the Air Force prefers Tx-N for the CRS transmit facilities.

2.1.6.2 Receive Site

Based on the COE contacts, landowners at Rx-E have shown a greater willingness than those at Rx-W to make land available for CRS. In addition, Rx-E receives runoff from a smaller off-site drainage area than does Rx-W, resulting in less severe hydrologic impacts from CRS construction at Rx-E. Consequently, the scale and complexity of necessary drainage improvements is expected to be less at Rx-E. Thus, to minimize socioeconomic and hydrologic impacts and mitigations, the Air Force prefers Rx-E for CRS receive facilities.

2.1.6.3 Power Supply

The alternative powerline corridors for both the transmit and receive sites do not vary significantly in terms of operational and constructability constraints or cost. Therefore, the Air Force's preference is to construct the CRS powerlines within the environmentally preferred

corridors, which are described in Section 2.3.3 - Comparison of Powerline Corridors. The environmental preferred corridors for the CRS transmit site are Links 1,3,5,6 and 9 would not differ for the Tx-N or Tx-S preliminary site layout. For the Rx-E site layout, the corridor connecting to the Dakota Junction substation is environmentally preferred.

2.2 ALTERNATIVES

2.2.1 Selection Process

2.2.1.1 Areas Considered and Rejected in the 1987 EIS

CRS will provide radar surveillance for near-shore areas along the Atlantic and Pacific Coasts which are not covered by the ECRS and WCRS. Its coverage area will overlap with the North Warning System in northeastern Canada, and will complete an arc of continuous OTH-B coverage across the Southern approaches to North America. *During the mid-1980s, the* Air Force examined a large area in the upper Midwest that fulfill those objectives for possible location of CRS facilities (see Figure 1.4.1). Grand Forks Air Force Base (AFB), North Dakota was selected as the site for the operations center. Given the need to locate the operations center at Grand Forks AFB and the overlap criteria for radar coverage in conjunction with the West Coast Radar System (WCRS) and the East Coast Radar System (ECRS), the site search area was narrowed to longitudes 94° - 98° West and latitudes 44.2°- 49° North, which includes eastern North and South Dakota and western Minnesota (see Figure 1.4.1). In that region, the Air Force applied a number of criteria, including avoidance of large population centers and major air corridors, to identify nine potential site search areas. Those nine areas were spread among Minnesota (4), North Dakota (4), and South Dakota (1).

The 1986 Draft EIS and the 1987 Final EIS examined the nine site search areas for locating CRS transmit and receive facilities. In conjunction with that EIS process, 10 scoping meetings and six public hearings were held in Minnesota and North and South Dakota. The Air Force

Record of Decision (ROD) of September 8, 1988 determined that the Amherst, South Dakota and the Wheaton North, Minnesota (about 70 mi east of Amherst, South Dakota) study areas were acceptable for transmit facilities. Because its larger size allowed greater flexibility in siting facilities, however, the Amherst study area had greater potential to minimize environmental impacts. For that reason, as well as logistical considerations, the Amherst study area was identified as the preferred location for the transmit facilities.

The 1987 EIS found that, of the five areas studied as possible receive sites, the Blanchard, North Dakota (about 70 mi southwest of Thief River Falls, Minnesota) and the Thief River Falls, Minnesota study areas were environmentally preferred. Because of its small size and proximity to a tall radio tower, the Blanchard area constrained the siting of CRS antennas. The Thief River Falls study area did not suffer from those constraints; consequently, the ROD identified it as the preferred study area for receive facilities. As directed by the ROD, this document examines alternative sites within the Amherst study area for the CRS transmit facilities and within the Thief River Falls study area for the CRS receive facilities.

2.2.1.2 Alternative Locations Within the Amherst and Thief River Falls Study Areas

Preferred Siting Areas—The selection of alternative Concentrated Study Areas (CSAs) and preliminary site layouts at the Amherst and Thief River Falls study areas were based on a three-phase process. In the first phase, general siting guidelines were applied to identify preferred siting areas. The general siting guidelines included the operational, environmental, and socioeconomic guidelines listed below:

Operational Guidelines

- The CRS sites should be 10 mi from population centers of 1,000 or more.
- The CRS transmit sites should be five mi from active railroads.
- The CRS sites should be five mi from transmissions towers.

- The site should have sufficient land available for four CRS sectors.

Environmental Guidelines

- Areas of high wetlands concentrations (>50 acres/mi^2) should be avoided.
- Areas with high concentrations of surface water bodies should be avoided.
- Areas of key wildlife habitat should be avoided.

Socioeconomic Guidelines

- Maximum use should be made of offered land.
- Public facilities should not be acquired for CRS use.
- Paved roads should be avoided.

Application of the siting guidelines resulted in the areas of lowest operational and environmental suitability being excluded from additional study. Two preferred siting areas were selected in each study area. In each case, one was environmentally preferred (based on minimization of wetlands impacts) and one was socioeconomically preferred (based on minimization of land condemnation). For the transmit site, the southern preferred siting area was environmentally preferred and the northern preferred siting area was socioeconomically preferred. For the receive site, the western preferred siting area was environmentally preferred while the eastern preferred study area was socioeconomically preferred.

Wetlands occupy 6% (5,970 acres) of the Amherst transmit study area and 6% (6,120 acres) of the Thief River Falls receive study area. Those wetlands are scattered throughout the study areas in the form of numerous potholes, rather than being concentrated in large complexes. In both study areas, each square-mile section contains at least 5 acres of wetlands. Because of the CRS land requirements and the scattered distribution of wetlands, CRS could not be sited within the study areas to avoid all wetlands. The siting guideline to avoid areas of high wetlands concentration was established to minimize wetlands impacts. Mitigation measures are listed in

sections 4.2.5 and 4.7.4 to compensate for wetlands impacts. Implementation of those measures will result in no net loss of wetlands, which is the current national goal.

To determine the socioeconomically preferred siting areas, the Air Force selected areas which would require the least amount of land acquisition from owners who do not wish to sell their property. The Air Force's land acquisition policy throughout the CRS EIAP, as stated in the 1988 ROD, was to minimize the condemnation of land from unwilling owners and to lease or purchase land according to the landowner's wishes.

Concentrated Study Areas—For the second phase of the site selection process, mammal and avian surveys and electromagnetic noise tests were conducted at the Amherst and Thief River Falls study areas, landowners were contacted to determine their willingness to sell or lease land, and meetings were held in Pierre, South Dakota and St. Paul, Minnesota with state and federal governmental agencies. The Air Force developed a screening process using information gained from the biological and electromagnetic studies, landowner surveys, and the agency meetings to select a concentrated study area (CSA) at each preferred siting area. The CSAs were selected to minimize environmental effects while utilizing offered land as much as possible.

The northern transmit CSA was defined to allow flexibility in the antenna configuration and to minimize socioeconomic impacts. The southern transmit CSA was located in the central portion of the preferred siting area to avoid impacts on the Augustana Cemetery, to avoid a large topographic depression in the southwestern part of the preferred siting area, and to minimize wetland impacts. The eastern receive CSA included lands offered for sale to the Air Force and was relatively distant from a transmitting tower in the southern part of the preferred siting area. The western receive CSA was the same as the preferred siting area because no new constraints were identified by the environmental studies or agency and landowner contacts. The alternative CSAs range in size from 12-26 mi^2, which is larger than the actual land requirements of 2-4 mi^2 for the transmit and receive facilities.

Preliminary Site Layouts—To select a preliminary site layout at each CSA, the Air Force used overlay maps containing information on roads, houses, drainage and hydrological features, land ownership, wetlands, avian concentration areas, topography, and vegetation. The objectives of this third phase were to minimize impacts on wetlands, native prairies, woodlots, avian flight paths, and roads, and to maximize use of offered land. At each CSA one preliminary site layout for CRS facilities was defined that best achieved these objectives. A 1,000-ft wide buffer zone is included on the perimeter of each layout to allow for shifting of facilities during final design and construction.

The Tx-N preliminary site layout is located in the extreme eastern portion of the CSA which contains the lowest possible concentration of wetlands within the CSA. The site layout also avoids native prairie which could be critical habitat for rare and endangered plants. All but one of the prairie-chicken leks within the CSA were also avoided; the one lek within the site layout is in the exclusion area and would not suffer direct construction impacts. The major factors influencing the selection of the Tx-S preliminary site layout were avoidance of roads and wetlands. The Tx-S layout does not affect either paved road in the CSA. The layout is also located in the area of lowest wetland concentration and the sectors are grouped as closely together as possible to minimize the area of affected wetlands.

The Rx-E preliminary site layout makes maximum use of land offers through a compact configuration of antennas developed specifically for this alternative. The compact arrangement of sectors also minimizes wetlands and habitat impacts. The layout is located west of the beach ridge trending north-south through the CSA that serves as a bird migration corridor and a heavy wildlife use area. The layout also avoids native tree stands in the eastern part of the CSA and does not affect any paved roads. The Rx-W preliminary site layout was chosen to minimize wetland and woodlot impacts. The four sectors were grouped as closely as possible and were sited in an area of relatively low wetland concentration. A major woodlot in the CSA was avoided, as were Routes 68 and 23, major gravel roads.

2.2.1.3 Analysis of Alternative Site Layouts

This EIS examines four alternative preliminary site layouts for the CRS facilities. Two layouts in South Dakota are candidates for the CRS transmit facilities. The other two layouts in Minnesota are candidates for the receive facilities. The objectives of this EIS are (1) to determine environmental effects that would result from construction and operation of CRS facilities at each preliminary site layout and alternative powerline corridors, and (2) to compare the levels of environmental impact that would occur at the alternative transmit-site layouts, receive-site layouts, and powerline corridors. This EIS reports the results of parallel investigations conducted at an equal level of detail for each of the four site layouts.

2.2.2 Alternative Transmit Locations

2.2.2.1 Regional Location

The two alternative CSAs proposed for CRS transmit facilities are in Brown and Marshall counties, South Dakota, situated in the James River Plain of the northeastern part of the state (see Figure 2.2.1). Aberdeen, the largest city and county seat of Brown County, is roughly 36 mi southwest of the northern CSA and 30 mi west–southwest of the southern CSA. U.S. Highway 12, which runs east–west, connects Aberdeen to the sites via county roads. Britton, the largest city and seat of Marshall County, is 16 miles northeast of the southern CSA and 10 miles southeast of the northern CSA (see Figure 2.2.1). The sites are accessible from Britton via county roads. Either of the two sites could function with the operations center at Grand Forks AFB and either of the two receive sites.

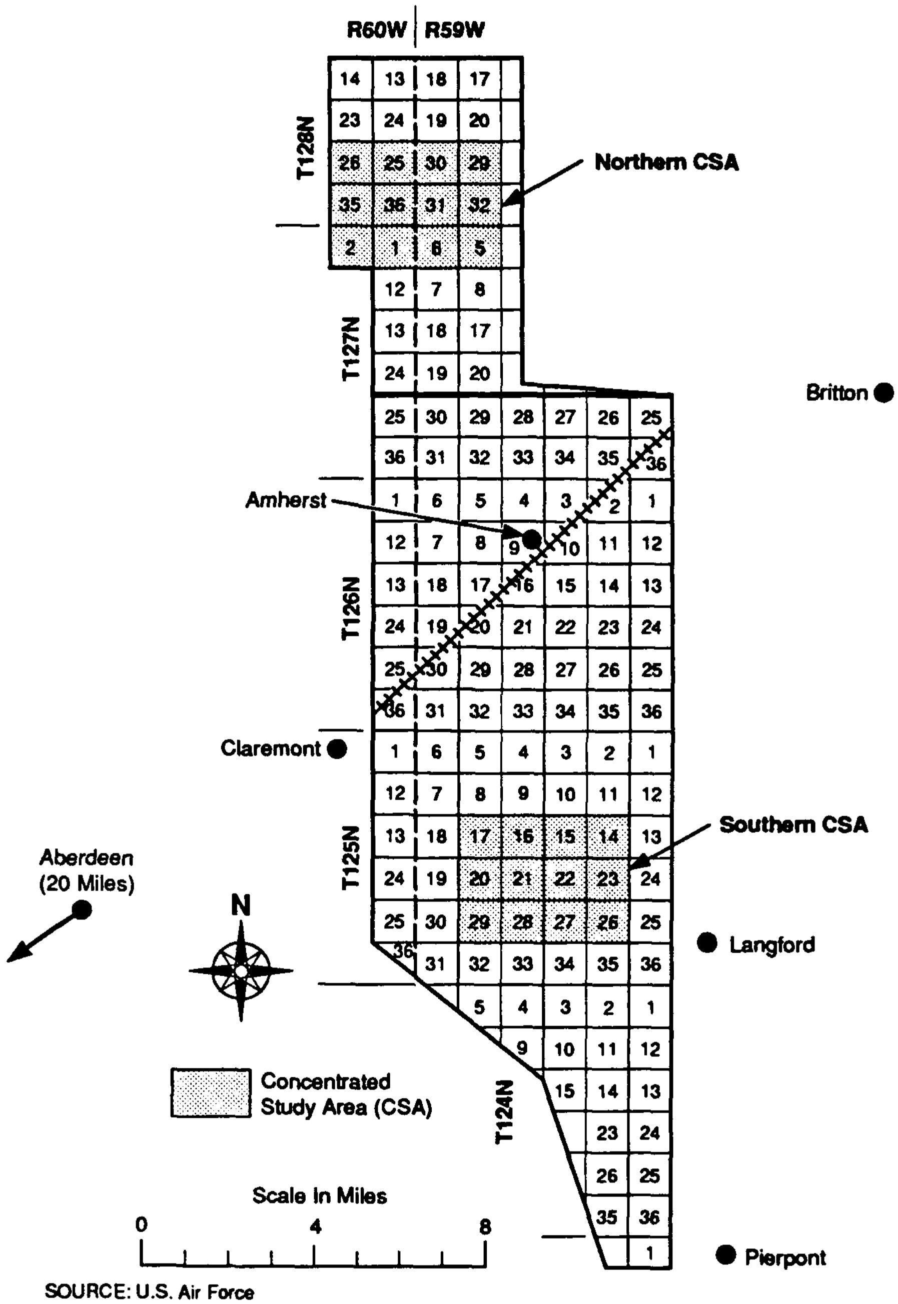


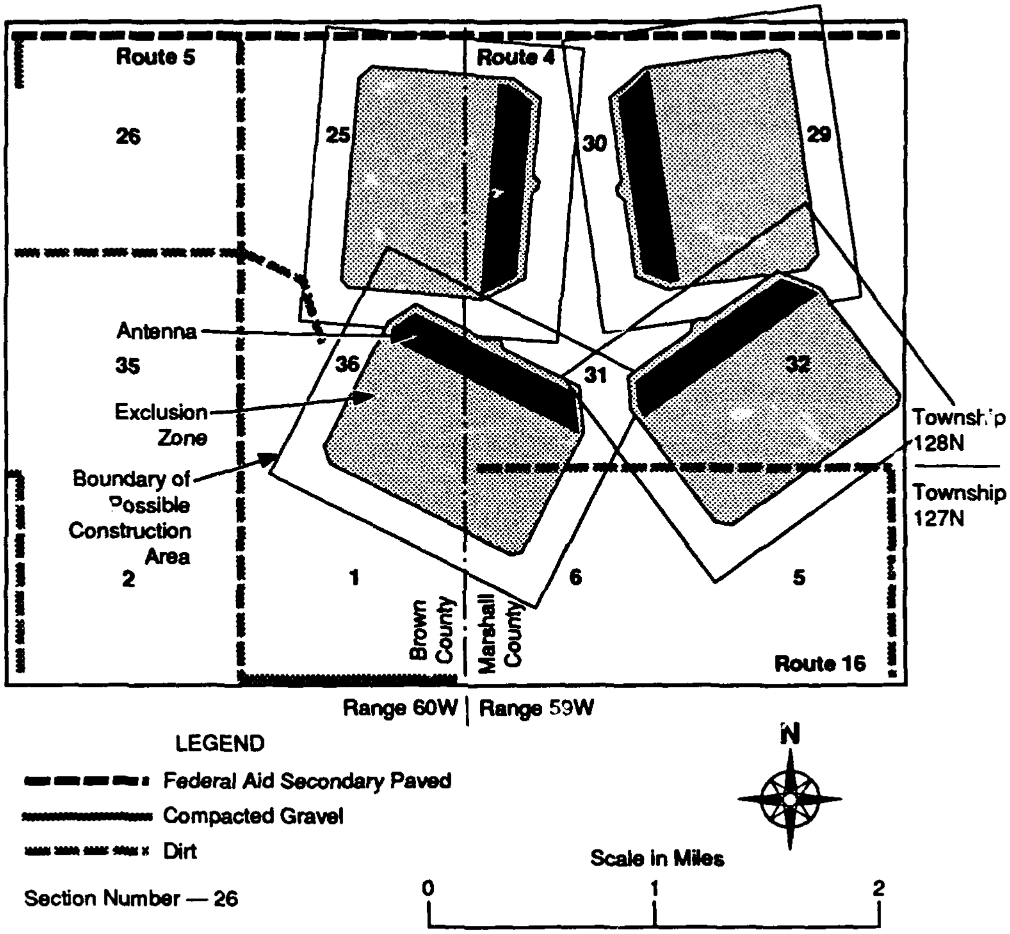
FIGURE 2.2.1 CONCENTRATED STUDY AREAS FOR CRS TRANSMIT SECTORS — AMHERST, SOUTH DAKOTA STUDY AREA

The western portion of Marshall County and the eastern portion of Brown County are relatively level, ranging in elevation from approximately 1,290-1,360 ft above mean sea level (msl). The area is rural, and the predominant land use in the vicinities of the CSAs is agriculture, with production of grain crops and livestock dominating.

2.2.2.2 Northern Preliminary Site Layout

The northern preliminary site layout (Tx-N) for CRS transmit facilities is located in Brown and Marshall counties, South Dakota about 7-10 mi north of Amherst and about 7-11 mi east of Hecla. This alternative would be in Dayton Township of Marshall County and Portage Township of Brown County and would include portions of Sections 29 - 32 of Township (T) 128 North, Range (R) 59 West; Sections 5-6 of T 127 North, R 59 West; Sections 25 and 36 of T 128 North, R 60 West; and Section 1 of T 127 North, R 60 West. Depending on the exact locations selected and and the need to acquire uneconomic parcels, between 2,000 and 4,000 acres could be acquired for CRS transmit facilities.

Elevations at Tx-N vary from 1,295-1,360 ft msl. Slope gradients are fairly gentle, ranging up to 5%. The topography is irregular, with many small basins interspersed with local high spots. The four transmit antennas would be arranged as shown in Figure 2.2.2. Any shifting of facilities during final design would be within the area labelled "boundary of possible construction area." The antennas would emit continuous-wave (cw) electromagnetic radiation, requiring an exclusion zone extending 4,000 ft in front of the antenna. The exclusion zone would be surrounded by a perimeter road for security patrols to prevent unauthorized entry. The size of the exclusion area and the physical characteristics of the antennas, access roads, and perimeter roads are described in Section 2.1.2.



SOURCE: U.S. Air Force

FIGURE 2.2.2 OTH-B CRS TRANSMIT SITE, Tx–N ALTERNATIVE

2.2.2.3 Southern Preliminary Site Layout

The southern preliminary site layout (Tx-S) for CRS transmit facilities is located 2-6 mi west of Langford, South Dakota and is entirely within Newport Township of Marshall County. The area that would be affected by land acquisition and facility construction would include portions of Sections 14–17, 20–23, and 26–29 of T125 North, R59 West. Depending on the exact location selected and adjustments for uneconomic parcels, between 2,000 and 4,000 acres would be acquired for construction of CRS transmit facilities .

Elevations at Tx-S vary from 1,295-1,320 ft msl. Slope gradients are gentle, being less than 2%. The drainage network of the area is poorly developed because of the lack of relief. Surface runoff predominantly drains to low-lying enclosed basins, where it collects until dissipated by evaporation, evapotranspiration, or ground infiltration. The transmit antennas would generally be arranged as shown in Figure 2.2.3. The facilities could be shifted somewhat during final design and siting, but any relocation would be within the area labelled "boundary of possible construction area."

2.2.3 Alternative Receive Locations

2.2.3.1 Regional Location

The two alternative CSAs proposed for CRS receive facilities are in Polk and Pennington counties, Minnesota, situated in the lowlands along the Red River of the North in northwestern Minnesota. Thief River Falls, at the confluence of Thief and Red Lake rivers and the largest city in the area, is 8-20 mi east of the two CSAs. Warren, on the Snake River, is located 8-21 mi west of the two CSAs. The sites are accessible from Thief River Falls and Warren via State Highway 1. Figure 2.2.4 shows the Thief River Falls study area and the two CSAs. Either of the

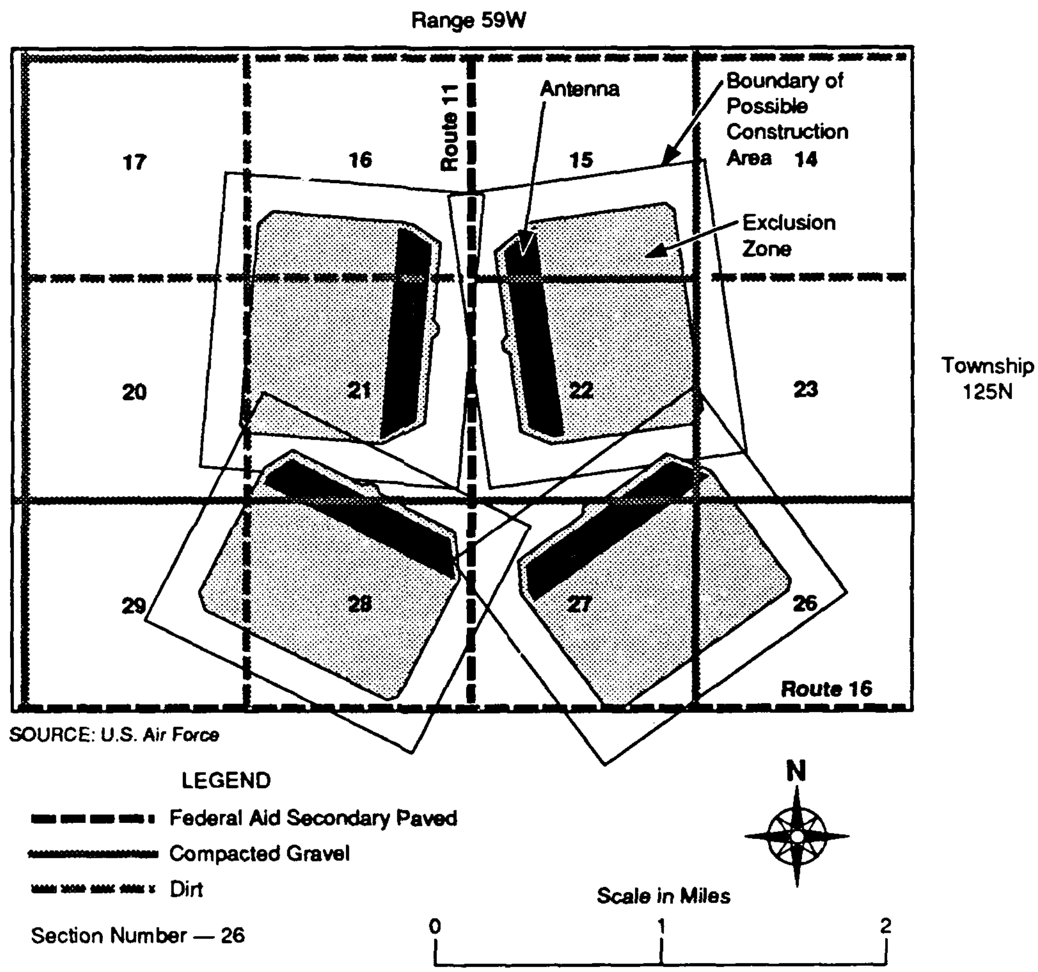


FIGURE 2.2.3 OTH-B CRS TRANSMIT SITE, Tx–S ALTERNATIVE

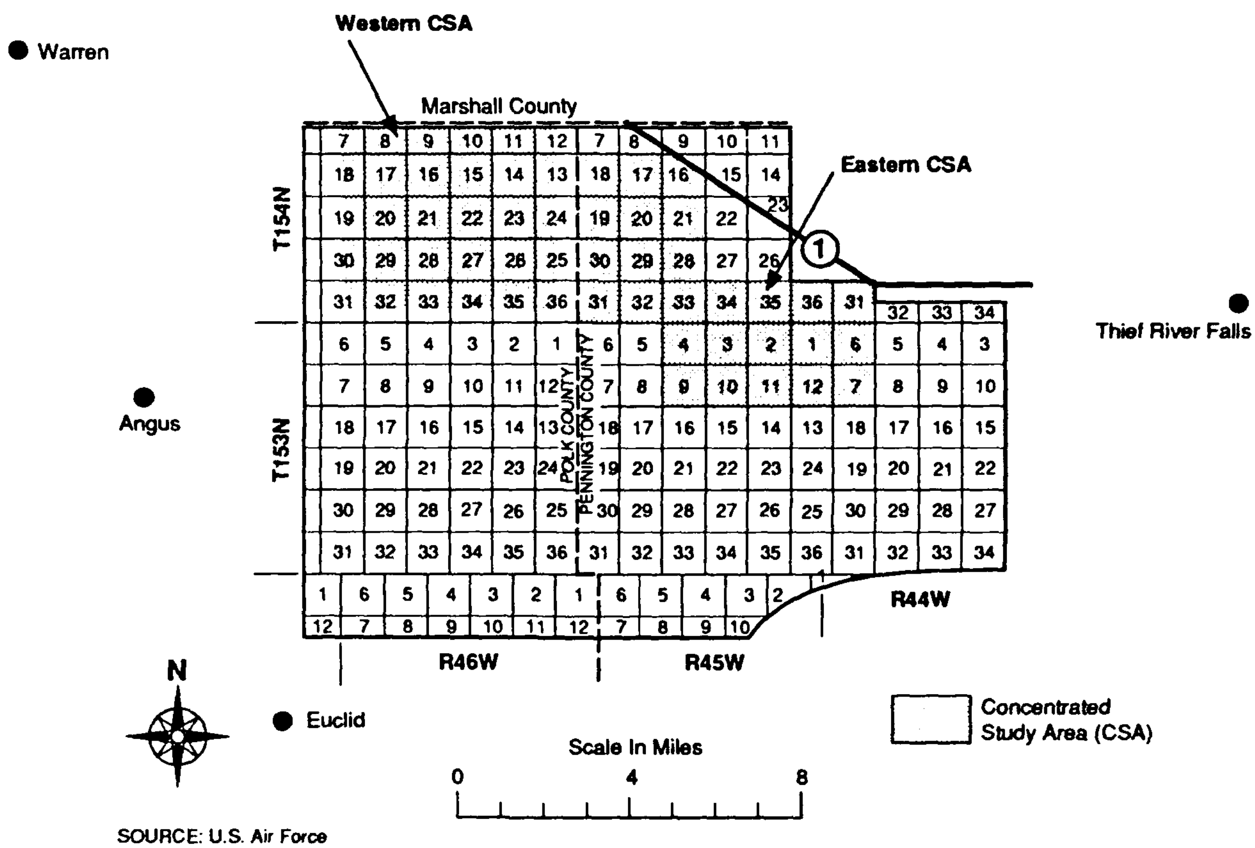


FIGURE 2.2.4 CONCENTRATED STUDY AREAS FOR CRS RECEIVE SECTORS — THIEF RIVER FALLS, MINNESOTA STUDY AREA

two receive CSA is operationally compatible with the operations center and either of the two transmit sites.

The western portion of Pennington County and the adjoining portion of Polk County are relatively flat and range in elevation from 850-1,150 ft above msl. Drainage is to the Red River of the North, about 43 mi west of Thief River Falls, which flows northward into Manitoba Province, Canada. The area is rural, and the predominant land use in the vicinity of the sites is agriculture, primarily grain crops and livestock.

2.2.3.2 Eastern Preliminary Site Layout

This preliminary site layout (Rx-E) for CRS receive facilities is located in northwestern Pennington County to the south of State Highway 1 and west of County Route 10. The antennas would be closely grouped with the east- and west-facing antennas in the center (see Figure 2.2.5). Slight shifting of facilities during final design is possible, but relocation would be within the area labelled "boundary of possible construction impacts." The facilities would be located in Numedal Township on portions of Sections 16-20 and 29-30 of T154 North, R45 West. Depending on the exact location selected for facilities and adjustments for uneconomic parcels, between 1,000 and 2,000 acres would be acquired. Elevations range from 975-1,005 ft msl. Slope gradients are less than 2%, and the site drains into man-made ditches flowing southward and westward.

The receive antennas would not emit radar signals. Consequently, the exclusion area would be for security and to prevent interference with reception. It would extend only 750 ft in front of the antenna. A fence and perimeter security road would surround each antenna. Physical characteristics of the receive antennas are described in section 2.1.3.

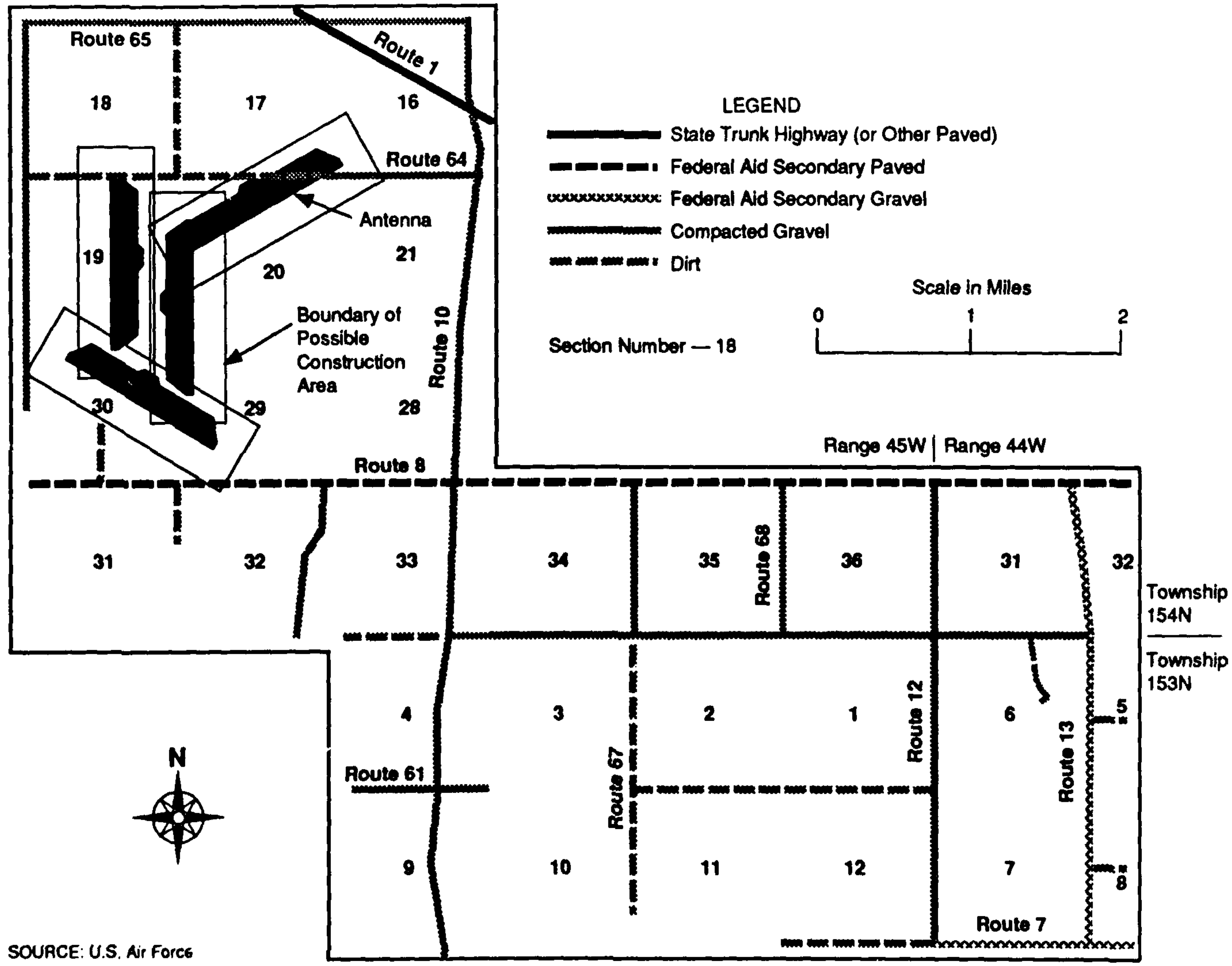


FIGURE 2.2.5 OTH-B CRS RECEIVE SITE, Rx-E ALTERNATIVE

2.2.3.3 Western Preliminary Site Layout

This preliminary site layout (Rx-W) for CRS receive facilities is located in the extreme northeastern corner of Polk County and is entirely within Helgeland Township. The area affected by land acquisition could include all or portions of Sections 15-18, 20-21, and 28-29 of T154 North, R46 West. Depending on the exact locations selected and adjustments for uneconomic parcels, between 1,000 and 1,600 acres would be acquired.

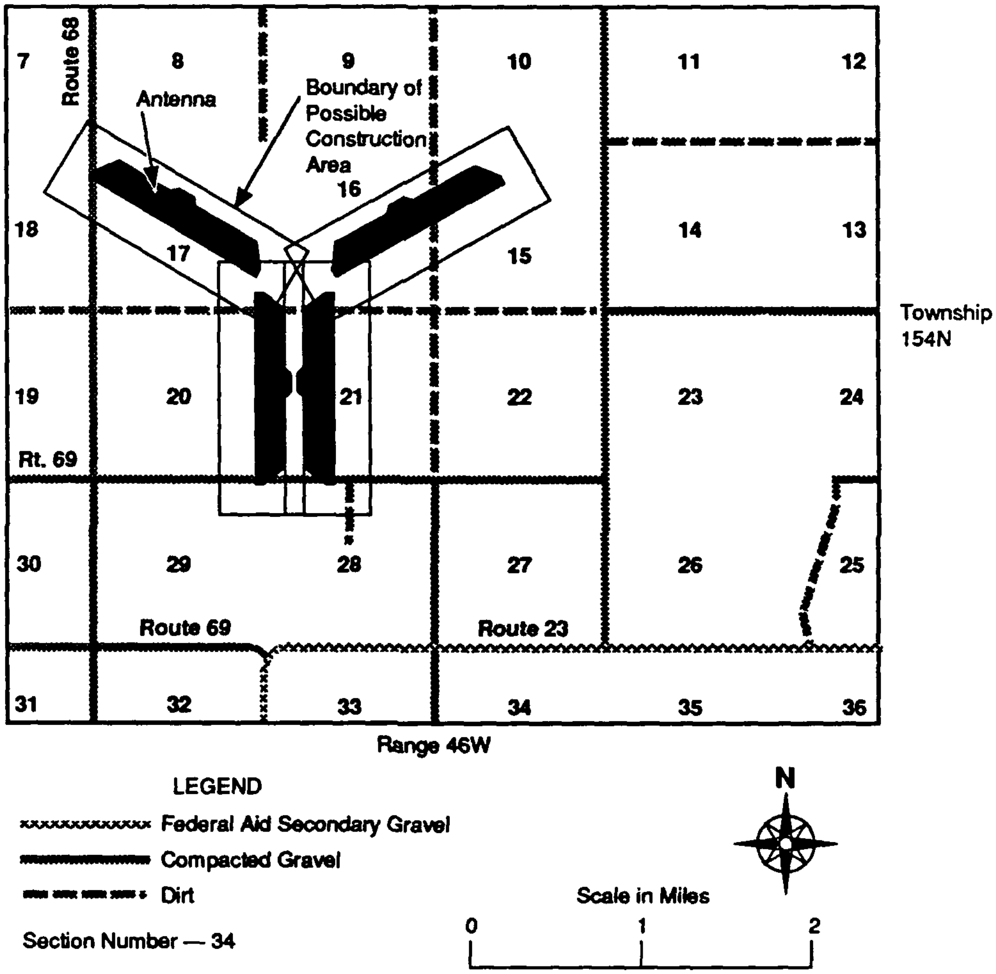
Elevations at Rx-W vary from 925-940 ft above msl. Slope gradients are less than 1%. Drainage is generally to man-made ditches that flow northward and westward to the Snake River, a tributary of the Red River of the North.

The receive antennas would be arranged as shown in Figure 2.2.6. Slight shifting of facilities during final design and construction is possible, but relocation would be within the area labelled "boundary of possible construction impacts."

2.2.4 Alternative Powerline Corridors

2.2.4.1 Transmit Site

To ensure a reliable power supply to the CRS transmit site, powerlines will connect the selected transmit site to both the Groton, South Dakota and the Forman, North Dakota substations. Based on the locations of those two substations and the alternative transmit sites, a 1,500 mi^2 area for powerline siting was identified by the Air Force in consultation with WAPA. That rectangular study area with Groton at the southwest corner and Forman at the northeast corner includes all probable areas for powerline siting. The James River and the Sand Lake and Dakota Lake National Wildlife Refuges were excluded from the study area because of heavy waterfowl use.



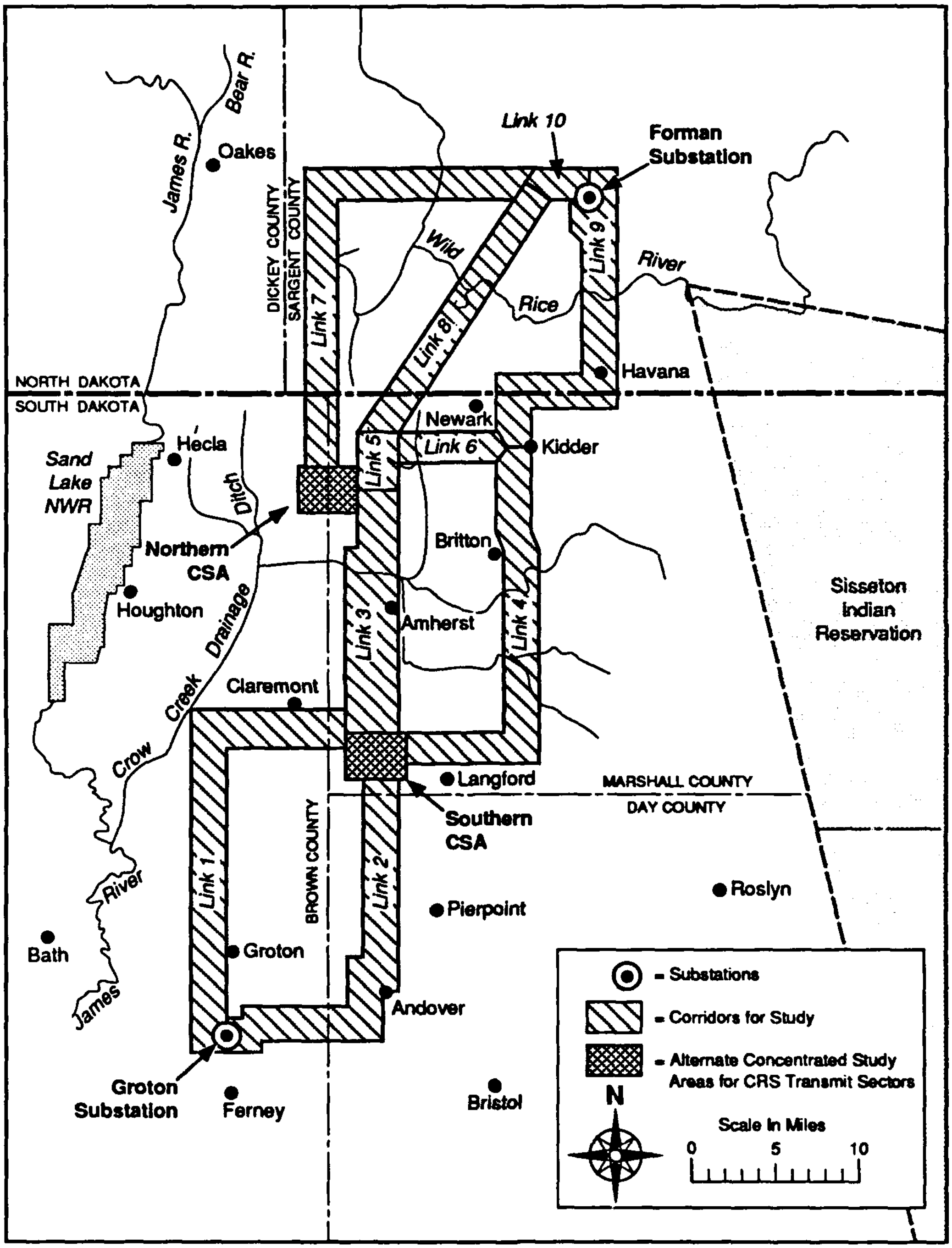
SOURCE: U.S. Air Force

FIGURE 2.2.6 OTH-B RECEIVE SITE, Rx–W ALTERNATIVE

Selection of alternative corridors (links) within the transmit-site powerline study area was based upon the need to avoid environmentally and culturally sensitive areas and to maximize use of existing ROWs, roads and powerline corridors. Exclusion areas, areas that the powerline should not cross, include national wildlife refuges, sites listed on the National Register of Historic Places, homes and public facilities, and local, state and federal parks and recreation areas. Avoidance areas, areas that the powerline should not cross unless there is no reasonable alternative, include semi-permanent and permanent wetlands, USFWS waterfowl production areas, state waterfowl management and game production areas, known or potential habitat for endangered species, population centers, and important natural resources (e.g. streams, shelterbelts, and prime farmland).

Information on exclusion and avoidance areas and existing roads and ROWs was transferred onto a base map of the powerline study area. Using that data, several 2-3-mi wide corridors were identified that avoid all of the exclusion areas and most of the avoidance areas described above. Because of their abundance in the study area, wetlands and cultivated farmland could not be completely avoided. Impacts to those resources will be minimized during selection of the actual powerline route. Because powerline corridors are 2-3-mi wide and the required ROW is less than 150-ft wide, there is considerable flexibility to shift the powerline routes within the corridors to minimize environmental effects.

This EIS examines the alternative corridors shown in Figure 2.2.7 to determine the potential for environmental effects. Table 2.2.1 identifies townships affected by each link. Section 2.3.3 compares the alternative corridors to determine the environmentally preferred corridors. Additional studies of environmental conditions of the preferred corridors are underway. Based on the results of those studies, 1,000-ft centerline routes will be selected by the Air Force in consultation with WAPA to keep environmental impacts as low as possible and operational reliability as high as possible. The centerline routes will then undergo further studies and will be adjusted as necessary, based on information gathered from field studies on natural and human



SOURCE: SRI International

FIGURE 2.2.7 ALTERNATIVE POWERLINE CORRIDORS FOR CRS TRANSMIT SITE

Table 2.2.1
TOWNSHIPS AND RANGES OF CRS TRANSMIT-SITE POWERLINE CORRIDORS

Link	Affected Townships and Ranges
1	T122N, R61W; T123N, R61W; T124N, R61W; T125N, R59W; T125N, R60W; T125N, R61W
2	T122N, R59W; T122N, R60W; T123N, R59W; T124N, R59W; T125N, R59W
3	T125N, R59W; T126N, R59W; T127N, R59W; T128N, R59W
4	T125N, R57W; T125N, R58W; T125N, R59W; T126N, R58W
5	T126N, R57W; T127N, R57W; T127N, R58W; T128N, R57W; T128N, R58W
6	T128N, R58W; T128N, R59W
7	T128N, R59W; T128N, R60W; T129N, R58W; T130N, R56W; T130N, R57W; T130N, R58W;
8	T128N, R59W; T129N, R58W; T129N, R57W; T130N, R56W; T130N, R57W
9	T128N, R57W; T128N, R58W; T129N, R55W; T129N, R56W; T130N, R55W; T130N, R56W; T131N, R55W
10	T130N, R56W; T131N, R56W

Source: SRI International

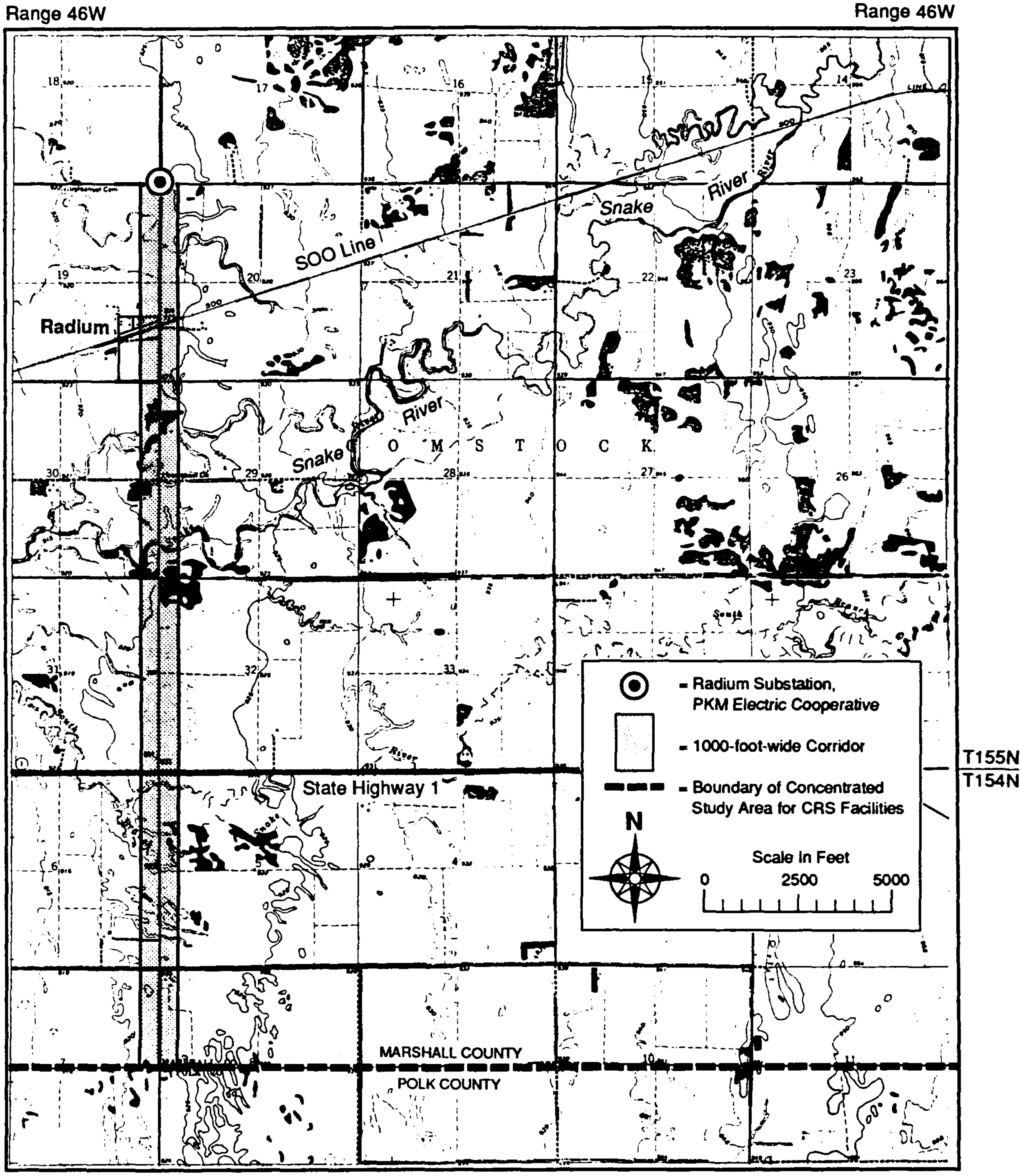
resources. The powerline route would generally be expected to parallel section lines, which typically have existing roads that would provide access to structure sites. Construction equipment would be able to travel overland from existing roads to most transmission structures.

2.2.4.2 Receive Site

State law dictates that the electric supplier for the CRS receive site be the cooperative with the franchise for the selected receive-site location. For Rx-E, the power supplier would be the Red Lake Electric Cooperative that serves Pennington County. For Rx-W, the PKM Electric

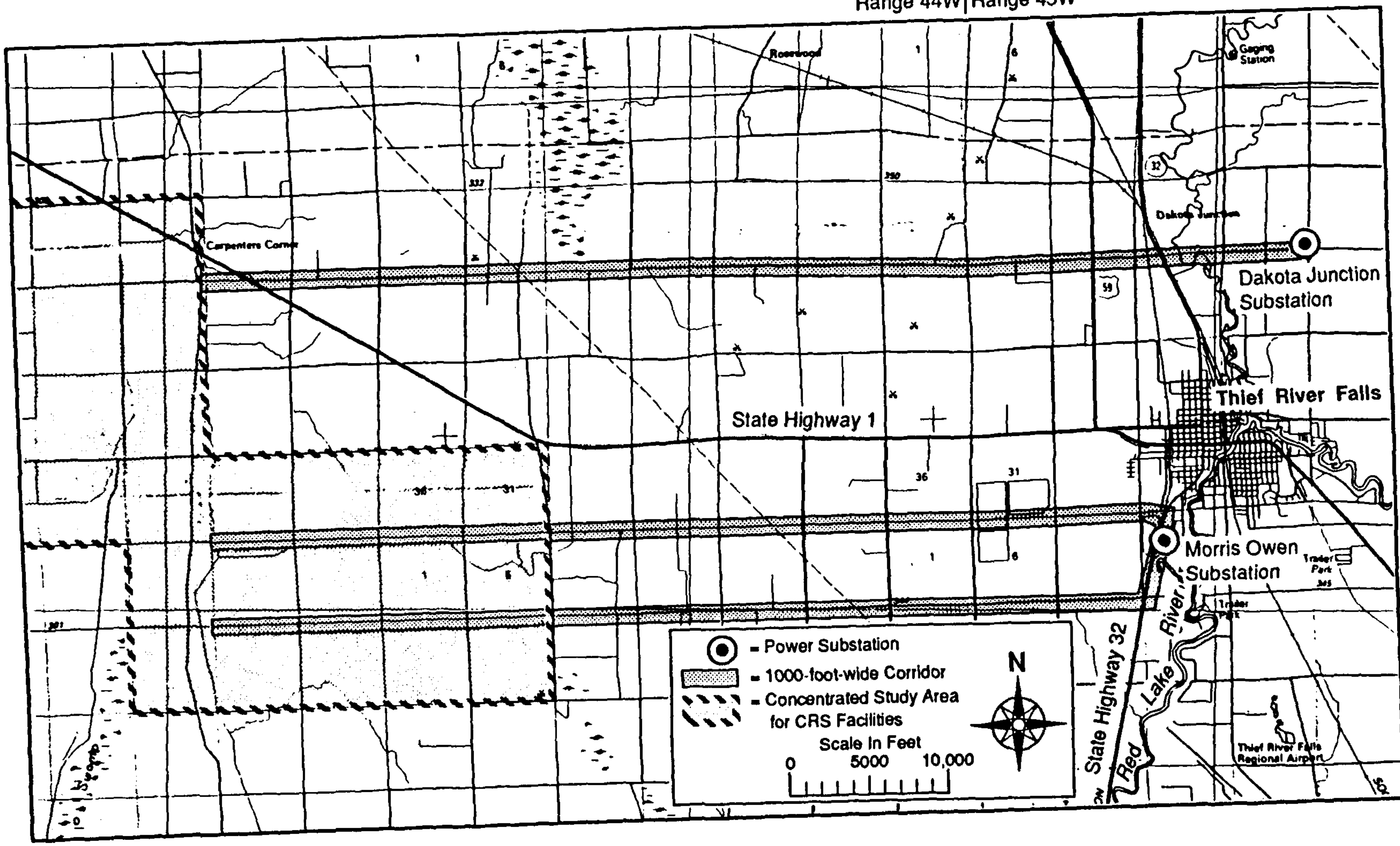
Cooperative that serves Polk County would supply electricity. Based on preliminary contacts with those cooperatives, possible routes for powerlines serving the receive site have been identified. Regardless of which alternative site and, therefore, electric cooperative is selected, the chosen cooperative would be required by the Rural Electrification Administration to prepare a BER. The BER will be prepared after the Air Force ROD selects a receive site and prior to powerline construction and will examine possible environmental impacts in detail. This EIS investigates impacts from construction and operation of the receive-site powerline at a somewhat broader level. The corridors examined in this EIS are 1,000-ft wide, but because the actual ROW required would be less than 80-ft wide, substantial flexibility to relocate the powerline within the corridor will exist.

The powerline route would depend on the site selected for the CRS receive facilities. If the Rx-W in Polk County is selected, Red Lake Electric Cooperative will construct a powerline connecting that site to the existing Radium Substation. The powerline would likely be routed directly south from the Radium Substation to the Rx-W site, parallel to an existing powerline and ROW. The total length of the line would be about 5.0 mi (see Figure 2.2.8). Assuming a 55-ft-wide ROW, total land area of the easement would be about 40 acres. If the Rx-E in Pennington County is selected, Red Lake Electric Cooperative will construct a powerline from either the Morris Owen or the Dakota Junction Substation near Thief River Falls to the receive site. The total line length would be about 13-15 mi for a line connecting to the Morris Owen Substation or about 13 mi for a line connecting to the Dakota Junction Substation (see Figure 2.2.9). Assuming a 55-ft-wide ROW, total land area of the easement would be 88-99 acres. The corridors shown in Figure 2.2.9 make maximum use of existing powerline and road alignments. The Red Lake Cooperative prefers the Dakota Junction Substation because it is farther from the City of Thief River Falls and because the line would cross the Thief River instead of the larger Red Lake River. If Rx-E is selected as the CRS receive site, the Air Force, in consultation with the Red Lake Electric Cooperative, would select the powerline route.



SOURCE: U.S.G.S. and SRI International

FIGURE 2.2.8 POWERLINE CORRIDOR FOR Rx-W



SOURCE: U.S.G.S. and SRI International

FIGURE 2.2.9 ALTERNATE POWERLINE CORRIDORS FOR Rx-E

2.2.5 Alternative Technologies

2.2.5.1 Airborne Warning and Control Systems (AWACS)

The ROD of September 8, 1988 considered several possible technological alternatives, but determined that no acceptable alternative system could serve the purpose of the CRS. A large number of Airborne Warning and Control Systems (AWACS) could provide surveillance of the 4 million mi^2 to be covered by CRS, but the purchase cost would be prohibitive because of the number of planes required. Each AWACS costs approximately $135 million. Additionally, the cost for basing and maintaining of a fleet of AWACS would significantly exceed the cost for operation of the CRS. Overall, the cost of purchasing and operating AWACS would be much greater than the cost for CRS.

2.2.5.2 Satellites

Surveillance satellites currently are unable to cover broad areas at high resolution as the CRS will. Although the Air Force is developing the required technology, designing, building, testing, and deploying such systems is expected to take 8 to 10 years. The development cost for a satellite system with wide-area surveillance capability would be significantly greater than that for a proven Over-the-Horizon Backscatter (OTH-B) system. Consequently, a satellite system is not considered a feasible alternative to CRS.

2.2.6 No-Action Alternative

Section 1502.14 of the Council on Environmental Quality Regulations that implement NEPA (40 CFR, Parts 1500-1508) requires that the alternative of no-action be examined in an EIS. Likewise, subparagraph 9.F.(2) of Air Force Regulation (AFR) 19-2 requires that the no action alternative be considered in an EIS. The 1986-87 EIS prepared for CRS examined the no-action alternative in Section 2.2.1, which defined that alternative as a decision to not construct

CRS. Under that alternative, no means of radar surveillance and tracking of hostile aircraft approaching North America would be available, and the U.S. would need to adjust its military strategies to accommodate the lack of information.

On September 8, 1988, James F. Boatright, Deputy Assistant Secretary of the Air Force (Installations), issued a ROD that determined that alternatives to CRS do not exist. This EIS builds on the analysis of the 1987 EIS by investigating, at a site-specific level of detail, alternative sites for the CRS transmit and receive facilities, as required by the earlier ROD. The 1987 EIS and 1988 ROD specifically considered and rejected the no-action alternative. Environmental and operational conditions have not changed sufficiently to justify altering that determination. Therefore, this EIS incorporates by reference the analysis of the no-action alternative included in the 1987 EIS and the subsequent ROD.

If the CRS is not constructed, the adverse environmental effects and the positive socioeconomic effects described in this EIS would not occur. The antenna sites at Tx-N, Tx-S, Rx-E, and Rx-W would remain in their existing condition—primarily in agricultural use. Construction impacts consisting of soil disturbance, hydrologic changes, filling of wetlands, dust generation, air emissions from construction vehicles, possible destruction of archeological resources, vegetation and habitat removal, and noise effects would be avoided. The natural setting of the CRS sites would remain in its current state. Similarly, impacts from construction of powerlines for the CRS transmit and receive sites would be avoided. However, beneficial job creation during CRS construction would also be forfeited.

Impacts projected to occur during CRS operation include the potential for electromagnetic interference, hazards to users of electroexplosive devices, removal of farmland from production, bird collisions with the CRS antennas and powerlines, visual impacts on historic properties, road closures, minor traffic generation, and fiscal impacts on local governmental agencies. Those impacts would be eliminated if the no-action alternative is implemented. Because agricultural activities would continue at the CRS sites, possible beneficial impacts on wetlands, vegetation,

and wildlife habitat from cessation of farming within the exclusion area would be forfeited. Increased employment due to CRS would also be eliminated.

Under this alternative, there would be no irretrievable commitment of resources and no cumulative impacts. The long-term productivity of the land would be unaffected.

2.3 Comparison of the Environmental Consequences of the Alternatives

2.3.1 Overview

Section 4 — Environmental Effects and Mitigation Measures — of this EIS analyzes the potential for impacts to the natural and human environment from construction and operation of the CRS and support facilities. That section also lists mitigation measures that, if implemented, would reduce the severity of the identified impacts. In some cases, however, the environmental impacts of the project cannot be fully mitigated and the impact remaining after mitigation would still be significant. This section compares the adverse environmental impacts that would result from CRS construction at the alternative transmit and receive preliminary site layouts and from powerlines for the transmit and receive facilities.

2.3.2 Comparison of Facility Sites

Table 2.3.1 lists environmental impacts that would result from construction and operation of CRS facilities at the alternative receive and transmit preliminary site layouts. The significance of the impacts given in Table 2.3.1 is that remaining after application of the mitigation measures listed in this EIS. Significant impacts are those that exceed established thresholds, such as concentrations of pollutants in air or water. Insignificant impacts are those that do not exceed the significance threshold. In some cases, the level of significance of an impact is indeterminate because the project details are incomplete or because lack of site access has prevented

Table 2.3.1

COMPARISON OF ENVIRONMENTAL CONSEQUENCES - CRS SITES

Impact	Transmit Sites		Receive Sites	
	Tx-N	Tx-S	Rx-E	Rx-W
Wind erosion of soil during construction	S	S	S	S
Water erosion of soil during construction	M	M	M	M
Rerouting of runoff flow patterns and elimination of flood storage capacity	M	PS	M	PS
Groundwater overpumping during construction	N	N	N	N
Fugitive dust generation during construction	S	S	S	S
Exhaust emissions fro' . construction and operations vehicles (other than dust)	M	M	M	M
Construction noise	S	S	S	S
Electromagnetic interference with television, radio, and air navigational systems	M	M	N	N
Hazards to pacemakers, EEDs, and fueling	M	M	N	N
Bioeffects of radiofrequency radiation	N	N	N	N
Removal of designated prime farmland and designated farmland of statewide importance	N	M	M	M
Wetlands filling	S	S	S	M
Bird collisions with antennas	S	S	S	S
Effects on threatened and endangered species	M	M	M	M

Table 2.3.1 (continued)

Impact	Transmit Sites		Receive Sites	
	Tx-N	Tx-S	Rx-E	Rx-W
Visual effects on historic properties	PS	PS	PS	N
Loss of recreational use at site	N	N	N	N
Job creation/population growth	B	B	B	B
Fiscal impact on school districts	M	M	M	M
Construction traffic	M	M	M	M
Road closures	M	M	M	M
Disturbance of archeological resources	M	M	PS	M

NOTE:	S	Significant adverse environmental impact
	PS	Potentially significant adverse impact
	M	Minor and insignificant adverse impact
	N	No impact
	B	Beneficial or positive effect

SOURCE: SRI International

determination of certain environmental conditions (e.g., the presence of a resource such as an archeological site or a rare plant species). In those situations, the impact is considered to be potentially significant.

Impacts on natural resources of the study areas would occur primarily, but not exclusively, during construction of the antennas and related facilities. Several hundred acres at the transmit and receive sites would be stripped of vegetation and graded for construction of the antennas, equipment buildings, roads, etc. As a result, site soils would be exposed to wind and water erosion, existing drainage patterns would be modified, and some wetlands would be filled. The site soils at all of the alternative soils are more prone to wind erosion than water erosion. Although measures could be taken to minimize the area of exposed soil and to control erosion of that soil, wind erosion is expected to be significant. Concentrations of dust particles in the air at the site and vicinity would temporarily exceed federal air quality standards, which would be a significant impact during the construction period only.

Alterations to drainage patterns and removal of existing flood-storage capacity would be a greater impact at Tx-S than at Tx-N and would also be greater at Rx-W than Rx-E. Tx-S and Rx-W receive much greater amounts of off-site runoff than Tx-N and Rx-E and also contain greater volumes of flood-storage capacity. In contrast, the acreage of wetland that would be filled during CRS construction would be greater at Tx-N than at Tx-S, and also greater at Rx-E than at Rx-W. Mitigation for hydrologic impacts would consist of improvements to drainage channels and installation of new facilities such as culverts, swales, and detention ponds. The federal government's no net loss of wetland policy would require that off-site wetlands be restored or created to replace the functional values loss due to filling of site wetlands. Impacts on wetlands at Tx-N are listed as significant because of the relatively large area—62 acres—that would be affected.

Construction of the CRS would generate up to several hundred vehicle trips per day, increasing traffic volumes on nearby roads and decreasing the level of service of some local roads from A to C. That would not be considered a significant impact because Level of Service C is acceptable. Construction vehicles would also generate exhaust emissions, but that would not result in exceedance of National Ambient Air Quality Standards. During the construction period, noise levels at nearby rural residence would increase by more than 5 dBA, which would be a temporary significant impact at any of the alternative sites.

At the CRS transmit site, the CRS electromagnetic signal could affect humans and wildlife and could interfere with other users of the electromagnetic spectrum. The CRS includes an exclusion area surrounding the transmit antennas to prevent human exposure to harmful levels of radiofrequency radiation. Outside the exclusion area, power densities would be well below standards for human exposure developed by the American National Standards Institute and implemented by Air Force Occupational Safety and Health (AFOSH) Standard 161-9, Exposure to Radiofrequency Radiation. CRS signals would use frequency bands not in use by other electromagnetic transmitters to minimize interference with amateur radio. Within a few miles of the transmit site, interference with television and radio reception could occur, but would be eliminated by installation of filters on the radio or television set.

CRS could affect biotic resources by creating a potential for bird collisions with the antennas and by harming threatened or endangered species. The transmit and receive study areas are within the Central Flyway, which is used by millions of migrating birds each year. The CRS antennas have been designed to minimize the likelihood of bird collisions, nonetheless, due to the number of birds present the collision potential would be a significant impact.

The CRS could also potentially affect federally listed threatened and endangered species through collisions with the antennas or destruction of habitat. Collisions with antennas could affect two threatened bird species, the bald eagle and the peregrine falcon, although that impact

is not expected to be significant. No effects are expected on the federally listed whooping crane, piping plover, eskimo curlew or gray wolf because they seldom, if ever, use the alternative sites. Field surveys for the federally listed burying beetle and the Western prairie fringed orchid were conducted during the summer of 1990 and biological assessments will be prepared to determine the level of project effect on those species.

Socioeconomic impacts from CRS would be insignificant. The CRS would result in a net increase of 110 jobs during construction and 15 jobs during operation. The removal of private property from property tax collection would reduce the revenues of county governments and school districts by less than 1.1%.

The CRS could alter the viewshed of potentially historic properties near Tx-N, Tx-S, and Rx-E; that impact would be significant only if the properties are found to be eligible for the National Register of Historic Places and eligibility is based on their setting. Further analysis of the properties will be needed to assess eligibility, therefore that impact is considered potentially significant. In a similar situation, Rx-E is located in a area of high potential for archeological sites because of its location near a beach ridge of glacial Lake Agassiz. If archeological resources are present, construction impacts could potentially be significant. However, the presence of such resources is unknown until an intensive archeological survey is conducted.

Comparison of the alternative transmit preliminary site layouts shows that significant impacts from wind erosion and dust generation, construction noise, and the potential for bird collisions with the transmit antennas would result at either preliminary site layout. A potentially significant environmental effect that could occur at either transmit site layout is visual effects on historic properties. More wetlands would be filled at Tx-N than at Tx-S, but impacts on surface flow patterns and runoff, flood-storage capacity, and highly productive farmland would be greater at Tx-S. Thus, there is no clear environmental preference between Tx-N and Tx-S for the transmit facilities.

Comparison of the alternative preliminary receive site layouts shows that significant impacts from wind erosion and dust generation, construction noise, and the potential for bird collisions with the receive antennas would occur at either preliminary site layout. Potentially significant impacts from alteration of drainage patterns and flood-storage capacity could result at Rx-W, However greater filling of wetlands would occur at Rx-E. Several listed plant and animal species and cultural resources are more likely to occur at Rx-E than at Rx-W; therefore, the likelihood of impacts on those resources is greater at Rx-E . In addition, visual impacts on historic properties could also be significant at Rx-E, but not at Rx-W. Consequently, Rx-W is environmentally preferred over Rx-E for the receive facilities.

2.3.3 Comparison of Powerline Corridors

To compare potential environmental impacts associated with the alternative powerline corridors, the number of stream crossings; the percentage of the corridor area in native prairie, grassland, cropland, woodlots, urban land uses, or irrigated farmland; and estimated archeological resource density were examined. In addition, the potential for bird collision hazards and effects on threatened and endangered species were determined (see Table 2.3.2).

For the transmit-site powerline, environmentally preferred corridors were identified connecting each substation (Groton, South Dakota, and Forman, North Dakota) to each site layout (Tx-N and Tx-S). The powerline connecting Tx-N to the Groton Substation could be located in either Links 1-3 or 2-3. Use of Links 1-3 would involve fewer stream crossings. There is little difference between the alternative corridors in terms of potential for impacts on wetlands, woodlots, grasslands, threatened and endangered species, urban land uses, and archeological resources. The potential for impacts on threatened and endangered species is low, and the birdcollision risk is moderate for both alternatives. More historic or potentially historic structures occur in and near Links 1-3 than Links 2-3, but most are within Groton and could be

Table 2.3.2
ENVIRONMENTAL COMPARISON OF POWERLINE CORRIDORS

CORRIDORS		Wetland (Percent)	Stream Crossings (Number)	Native Prairie (Percent)	Cultivated Land (Percent)	Grassland (Percent)	Woodlots (Percent)	Irrigated Land (Percent)	Bird Collision Risk	Potential Threatened Endangered Species	Urban Area (Percent)	Potential Archeolog. Resources
TRANSMIT	**SITE**											
Groton/ Tx-N	1-3	5	13	n/a	45	43	1	n/a	Mod	Low	1	Mod
	2-3	5	28	n/a	56	31	1	n/a	Mod	Low	1	High
Forman/ Tx-N	10-7	10	11	22	40	35	<1	5	High	Low	<1	High
	10-8-5	10	9	21	49	30	1	1	Mod	Low	<1	High
	9-6-5	8	2	11	62	30	1	0	Mod	Low	<1	High
Groton/ Tx-S	1	5	9	n/a	49	43	1	n/a	Mod	Low	1	Mod
	2	3	24	n/a	66	23	<1	n/a	Mod	Low	1	High
Forman/ Tx-S	10-8-5-3	7	13	14	44	36	1	1	Mod	Low	1	High
	9-6-5-3	6	6	9	54	34	1	0	Mod	Low	<1	High
	9-4	6	24	11	64	28	<1	3	Mod	Low	<1	High
RECEIVE	**SITE**											
Rx-W	Radium	2	7	0	75	0	8	0	Low	Low	1	High
Rx-E	Dakota Junction	3	2	n/a	n/a	n/a	11	0	Low	Low	0	V.High
	Morris Owen No.	6	1	n/a	n/a	n/a	23	0	Low	Low	3	V. High
	Morris Owen So.	5	2	n/a	n/a	n/a	18	0	Low	Low	0	V. High

NOTES: N/A: Information not available.
Stream Crossings: Includes all intermittent and permanent streams.
Cultivated Land: Approximate because area changes yearly.
Archeological Impacts: Potential for impacts at transmit-site corridors is low and at receive-site corridors is high, ratings are relative to other corridors.

SOURCE: Metcalf & Eddy/Holmes & Narver. SRI International

avoided during final route selection. Although the difference between the alternatives in potential for adverse environmental impacts is not great, Links 1-3 are environmentally preferred.

The powerline connecting Tx-N to the Forman Substation could be located within Links 10-7, 9-6-5, or 10-8-5. Of those alternatives, selection of Links 9-6-5 would minimize the potential for impacts on native prairie, irrigated farmland, birds, and visual resources. Links 9-6-5 would also have the fewest stream crossings. The potential for construction impacts on wetlands, grasslands, woodlots, threatened and endangered species, urban land uses, and archeological resources would not differ significantly among the alternatives. A powerline located within Links 10-7 would have the highest potential for bird collisions. Therefore, Links 10-7 or 10-8-5 would create a somewhat greater potential for adverse impacts, and Links 9-6-5 are environmentally preferred.

The powerline connecting Tx-S to the Groton Substation could be located within Link 1 or 2. Link 1 avoids a large wetland at the southwestern portion of the CSA and would require fewer stream crossings than Link 2. The potential for impacts on woodlots and threatened and endangered species and for bird collisions is similar for the two links. Use of Link 1 would result in lower potential for impacts on archeological resources than use of Link 2. Therefore, Link 1 is slightly preferable from an environmental standpoint.

The powerline connecting Tx-S to the Forman Substation could be located within Links 10-8-5-3, 9-6-5-3, 10-7-5-3, or 9-4. The potential for impacts on threatened and endangered species, native prairie, woodlots, irrigated farmland, and archeological resources does not vary significantly among the corridors. Use of Links 10-7-5-3 would result in the highest potential for bird collisions. Selection of Links 9-6-5-3 would minimize the potential for impacts on wetlands and streams because it contains the lowest percentage of wetland area and the fewest stream crossings of the alternatives. Thus, Links 9-6-5-3 are environmentally preferred.

Three powerline corridors for Rx-E and one corridor for Rx-W were analyzed. At Rx-E, using the corridor connecting to the Dakota Junction Substation would result in lower potential for impacts on wetlands, woodlots, and urban land uses than using the corridors connecting to the Morris Owen Substation. In addition, the Dakota Junction corridor crosses the Thief River while the two Morris Owen corridors cross the much larger Red Lake River. For those reasons, the Dakota Junction corridor is environmentally preferred.

Because of the relatively short distance between the Radium substation and Rx-W, only one corridor following the most direct route is analyzed in this EIS. Construction of the CRS powerline within that corridor could potentially result in impacts on farmland, woodlots, wetlands, and archeological resources. None of those impacts would be significant .

3. AFFECTED ENVIRONMENT

Section 3 discusses the environmental characteristics of the alternative sites under consideration for Over-the-Horizon Backscatter (OTH-B) Central Radar System (CRS). The discussion covers the alternative preliminary site layouts for the CRS transmit and receive facilities as well as the alternative power supply corridors.

3.1 GEOLOGY AND SOILS

3.1.1 Transmit Study Area

3.1.1.1 Bedrock and Surficial Geology

Western Marshall and eastern Brown counties in South Dakota are within the Lake Dakota plain of the Central Lowland physiographic province. Glacial sediments deposited from Lake Dakota generally overlie bedrock that is of Cretaceous age or older (greater than 66 million years ago). Bedrock consists of sedimentary layers and granite. (Koch, 1975; Leap, 1986). The oldest bedrock unit at the transmit study area is granite of Pre-Cambrian age (more than 565 million years ago) and is part of the continental shield. That granite occurs at about 900-1,100 ft below the ground surface. The upper boundary of the granite is an erosional surface, and no layers of the Paleozoic or the early to middle Mesozoic eras occur under the sites. Overlaying the granite are 800-900 ft of sedimentary layers of Cretaceous age (66 to 145 million years ago), including, in order of decreasing age, the Dakota formation, the Graneros shale, the Greenhorn Limestone, the Carlile Shale, the Niobrara Formation, and the Pierre Shale. These Cretaceous-age units consist of marine sediments, primarily shales interspersed with thin layers of siltstones, sandstones, and limestones. In the late Cretaceous period, the area was elevated above sea level and eroded, forming an erosional surface at the upper boundary of the Cretaceous units. No Tertiary-age units

are present. During Quaternary time (the past 1.8 million years), glacial and postglacial sediments were deposited above the Cretaceous layers. Glacial deposits consist primarily of lacustrine (deposited in a lake) clays, silts, and sands from Lake Dakota, although glacial till deposited directly from the glacial ice may underlie the lacustrine deposits. In most areas, loess and alluvium of Holocene age (less than 10,000 years ago) overlay the glacial sediments and are present at the surface. The extreme northwestern portion of Marshall County in particular has large areas covered by wind-blown loess. The total thickness of the Quaternary deposits ranges up to 65 ft . (Koch, 1975; Leap, 1986)

Tx-N is covered at the surface by dunes composed of grayish-brown to brownish gray fine-to-medium sand. This deposit ranges in depth from several to tens of ft and is underlain by Lake Dakota sediments. Those dunes formed from wind-blown silts and sands from the Lake Dakota. The dunes are generally stabilized now with vegetation, but scattered areas of erosion and sediment transport occur where the vegetation has been disturbed. (Koch, 1975 and Leap, 1986)

Tx-S is covered by clays, silts, and sand deposited from Lake Dakota during the Pleistocene epoch (10,000 to 1.8 million years ago). Those deposits range up to tens of ft in thickness and are yellowish-brown to light gray in color. Small areas of Holocene alluvium may occur along drainages, although natural channels have generally been replaced by man-made ditches. (Koch, 1975)

3.1.1.2 Groundwater

Groundwater occurs within Holocene alluvium, Quaternary glacial deposits, and Cretaceous sedimentary rocks underlying Marshall and Brown counties. The Pre-Cambrian granites at depth lack sufficient pore space and permeability to store significant amounts of water. The shallowest aquifer, the James aquifer, is contained within alluvium and glacial deposits within 111 ft of the ground surface. Yields of up to 500 gallons per minute (gpm) have been reported from that aquifer. In the vicinity of the CRS sites, however, more modest yields of 2-25 gpm have been reported. (Metcalf & Eddy/Holmes & Narver, 1990B) At depths of up to several-hundred ft

under the study area, the Pierre Shale and the Dakota formation aquifers occur. Reported yield for the Pierre shale aquifer is 5 gpm and for the Dakota formation aquifer is 200 gpm. Of these three aquifers, the James River occurs only at Tx-N; the other two occur at both Tx-N and Tx-S. (Koch, 1975)

3.1.1.3 Seismicity

The north-central United States is located on the tectonically stable North American craton and seismic activity is very limited. Since 1872, three earthquakes of Modified Mercalli intensities III-IV have been recorded with epicenters within 50 mi of the CRS transmit sites (Reagor, 1981B and 1981C). South Dakota is mapped as Seismic Zone 1, which has a very low likelihood of a strong earthquake. The seismic risk to any structures is minimal. (Metcalf & Eddy/Holmes & Narver, 1990B)

3.1.1.4 Economic Geology

The most important mineral resources of Brown, Day, and Marshall counties are sand and gravel. The largest supply of economic grade sand and gravel is found in the Coteau des Prairies located 8-16 mi east of the sites. Clay deposits are present in the counties, but the high carbonate content makes them unsuitable for production of high-quality brick. No commercial gas or oil supplies are known to exist in the three counties. (Leap, 1986 and 1988; Koch 1975)

3.1.1.5 Soils

The U.S. Department of Agriculture Soil Conversation Service (SCS) has mapped the soils of the CRS transmit study area at both the soil association and the more detailed soil series level. The Brown County soil survey has not been published; therefore, soil data were obtained from the Marshall County Soil Survey only. Tx-N includes soils of the Maddock-Serden and the Embden-Hecla-Ulen associations. Tx-N is almost level to hilly, has generally well-drained loamy and sandy soils, and is formed in eolian and lacustrine sands. Soil series at Tx-N and their properties

Table 3.1.1
PROPERTIES OF SOILS AT TX-N

Soils Series	Capability Class[a]	Shrink-Swell Potential	Limitations		Drainage	Erosion Potential[b]
			Septic Systems	Roads		
Arveson fine sandy loam	V	Low	Severe[c]	Severe[d]	Poor	High
Hamar fine sandy loam	III	Low	Severe[c]	Severe[d]	Poor	High
Hecla-Hamar loamy fine sands	IV	Low	Slight	Slight	Good	High
Hecla-Venlo complex, eroded	VI	Low	Slight/mod	Slight	Good	High
Maddock loamy fine sand, 2-6% slopes	IV	Low	Slight	Slight	Good	High
Maddock loamy fine sand 6-15% slopes	VI	Low	Slight	Slight	Good	High
Marsh	VIII				Poor	
Serden fine sand, eroded	VI	Low	Slight	Slight	Good	High
Serden-Venlo complex	VI	Low	Slight	Slight	Good	High
Ulen fine sandy loam	III	Low/mod	Severe[c]	Mod[e]	Good	High
Ulen Stirum fine sandy loams	III	Low/mod	Severe[c]	Mod[e]	Good	High

a Ranked on a scale of I to VIII with I being most productive farmland and VIII being least productive.
b Wind blowing is the primary erosion hazard.
c Limitation due to high groundwater.
d Limitation due to poor drainage.
e Limitation due to flood hazard.

Source: Schultz, 1975

are listed in Table 3.1.1. The agricultural productivity of the site soils is moderate to poor, with the least productive series being poorly drained or eroded. Shrink-swell potential is generally low, which is desirable from an engineering standpoint, and drainage is good for most of the site. In some portions of the site, high groundwater limits the effectiveness of septic systems. Runoff is generally slow, and water erosion is much less of a hazard than soil blowing, which is a severe problem in areas of vegetation disturbance. (Schultz, 1975)

Tx-S is located on areas of Embden-Hecla-Ulen, Beotia-Great Bend, and Harmony-Aberdeen-Exline soil associations. Those associations consist of nearly level loamy, silty, and sandy soils formed mainly from lacustrine and glacial outwash sands and silts. Drainage varies from poor to good. Table 3.1.2 shows soil series found at the site and their properties. Many of the soils on site have high agricultural productivity with Capability Classes ranging from II to IV. Roughly half of the soil series have high shrink-swell potentials. Limitations for septic systems and roads are severe through much of the site, mainly as a result of high groundwater levels, low soil permeability, and poor drainage conditions. The erosion potentials of the various soil series vary considerably, with the most significant hazard from wind blowing. (Schultz, 1975)

3.1.1.6 Topography and Erosion

Tx-N is nearly level but has a gradual upslope on the eastern portion and dormant sand dunes on the western portion. The ground generally slopes downward to the west and south. Elevations vary from 1,360 ft msl in the northeastern corner of the site to 1,295 ft msl in the southwestern corner. The sand dunes on site are imposed upon the overall ground slope and reach heights of 10-30 ft. The primary erosion hazard is the wind because the low slope gradients (less than 5% throughout the site, and generally 1-2%) prevent rapid collection and runoff of stormwater and because the silty and sandy soil is susceptible to wind transport. Areas denuded of vegetation are prone to severe wind erosion, resulting in formation of blowouts and dunes. Dunes on the site have formed in the past 10,000 years, with many resulting from poor agricultural practices in the

Table 3.1.2
PROPERTIES OF SOILS AT TX-S

Soils Series	Capability Class[9]	Shrink-Swell Potential	Limitations		Drainage	Erosion Potential
			Septic Systems	Roads		
Arveson-Exline silty clay loams	III	Mod/high	Severe[b]	Severe[c]	Mod	Low
Bearden silt loam	II	Low/mod	Severe[d]	Severe[e]	Poor	High[f]
Beotia silt loam	II	Low/mod	Mod	Mod	Good	Low
Beotia-Bearden silt loams	II	Low/mod	Mod	Mod	Good	High[f]
Colvin silty clay loam	IV	Mod	Severe[e]	Severe[g]	Poor	None
Dovray silty clay	II	High	Severe[b]	Severe[c]	Poor	None
Embden fine sandy loam	III	Low	Slight	Mod	Good	High[f]
Exline-Aberdeen silty/clay loams	VI	Low/high	Severe[b]	Severe[c]	Poor	None
Great-Bend-Beotia/silt loams	II	Low/mod	Mod	Severe	Mod	Low
Great Bend-Zell silt loams	III	Low/mod	Mod	Severe	Mod	High[f]
Hamar fine sandy loam	III	Low	Severe [d]	Severe[g]	Mod	None
Harmony-Aberdeen silty clay loams	II	Mod/high	Mod	Severe[g]	Mod	Low
Hecla-Hamar loamy fine sands	IV	Low	Slight	Slight	Good	High[f]
Lamoure silty clay loam	II	Mod/high	Severe[d]	Severe[g]	Poor	None
Ludden silty clay	II-IV	High	Severe[d]	Severe[g]	Poor	None
Oldham silty clay loam, saline	IV	Mod/high	Severe[d]	Severe[g]	Poor	None
Parnell silty clay loam	III	High	Severe[g]	Severe[c,g]	Poor	None
Stirum-Ulen fine sandy loams	IV	Low	Severe[d]	Severe[g]	Poor	High[f]
Tonka silt loam	II/IV	Low/high	Severe[b]	Severe[c]	Poor	None
Ulen fine sandy loam	III	Low/mod	Severe[d]	Mod	Good	High[f]
Ulen-Stirum fine sandy loams	III	Low/mod	Severe[d]	Mod	Good	High[f]

Table 3.1.2 (Continued)

[a] Ranked on a scale of I to VIII with I being most productive farmland
[b] Limitation due to low permeability of soil.
[c] Limitation due to high shrink-well potential.
[d] Limitation due to *high groundwater*.
[e] Limitation due to frost heave potential.
[f] Blowing hazard.
[g] Limitation due to flooding hazard.

Source: Schultz, 1975.

past 1,000 years. Figure 3.1.1 shows areas of existing active wind erosion (blowouts) and active water erosion (gullies and rills).

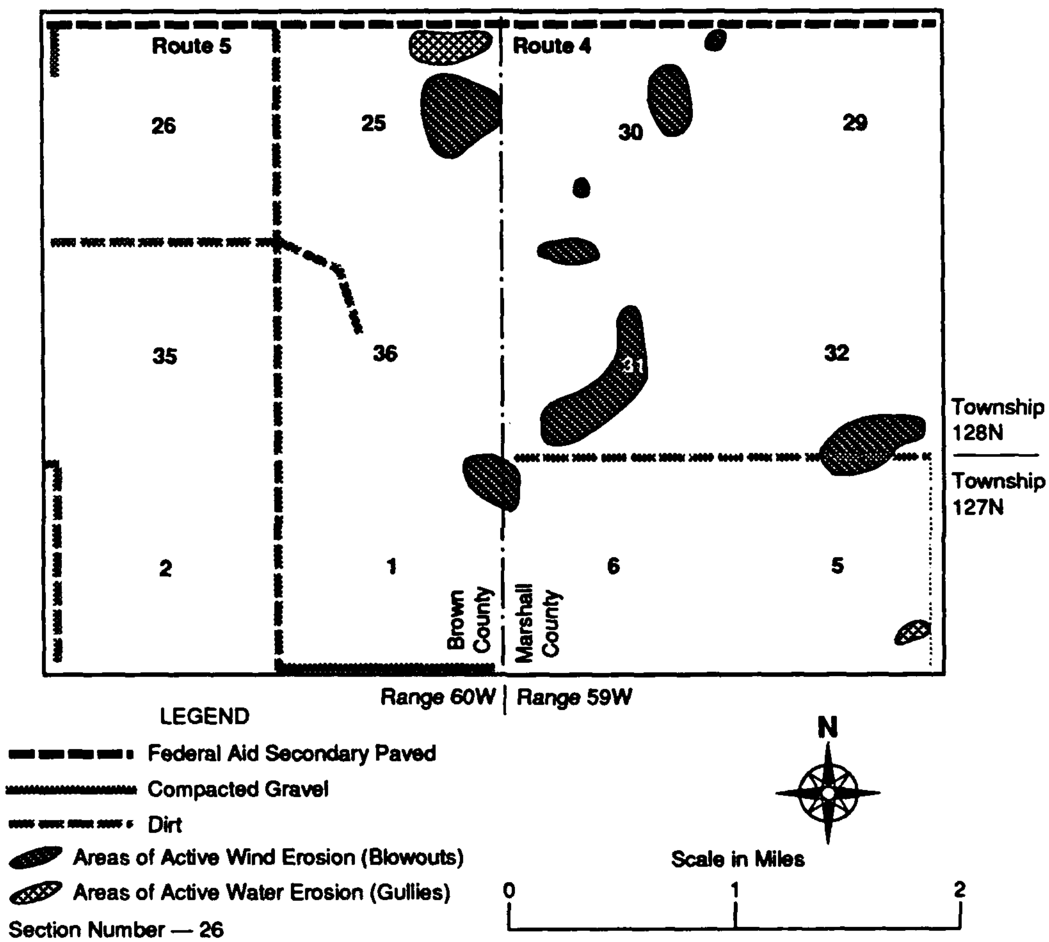
Tx-S is level with less relief than at the northern site. Elevations vary from 1,320 ft msl in the southeastern corner of the site to 1,295 ft msl along the north central site boundary. Slope gradients are less than 2% throughout the site, with much of the area sloping at less than 1% gradient. The potential for wind erosion is less than at Tx-N because of the lower silt content of the soils, and no dunes appear to be present. Limited erosion in the form of bank caving and gully formation is present along intermittent drainages of the area, as shown in Figure 3.1.2.

3.1.2 Receive Study Area

3.1.2.1 Bedrock and Surficial Geology

The CRS receive study area is located in the *Glacial* Lake Agassiz Plain physiographic province. During the Pleistocene epoch (10,000 to 1.8 million years ago), portions of western Minnesota, the eastern Dakotas, and adjacent Canada were covered by Lake Agassiz. The lacustrine sedimentary units deposited in Lake Agassiz and the beach deposits that formed along its shoreline are the primary superficial layers of the area and strongly influence the current topography of the study area. Underlying the Lake Agassiz deposits are crystalline basement rocks. (Minnesota Geological Survey, 1979)

The basement rocks of the alternative receive sites are lower Pre-Cambrian (more than 2.6 billion years ago) crystalline rocks, including granite and metamorphics of the amphibolite and greenschist facies. Based on aeromagnetic and gravity data, the basement rocks under the receive study area are interpreted to be granite. No units from the Paleozoic through the Tertiary age (565 to 2 million years ago) are known to overlie the basement granites. The upper erosional surface of



SOURCE: SRI International

FIGURE 3.1.1 EROSION CONDITIONS AT Tx–N

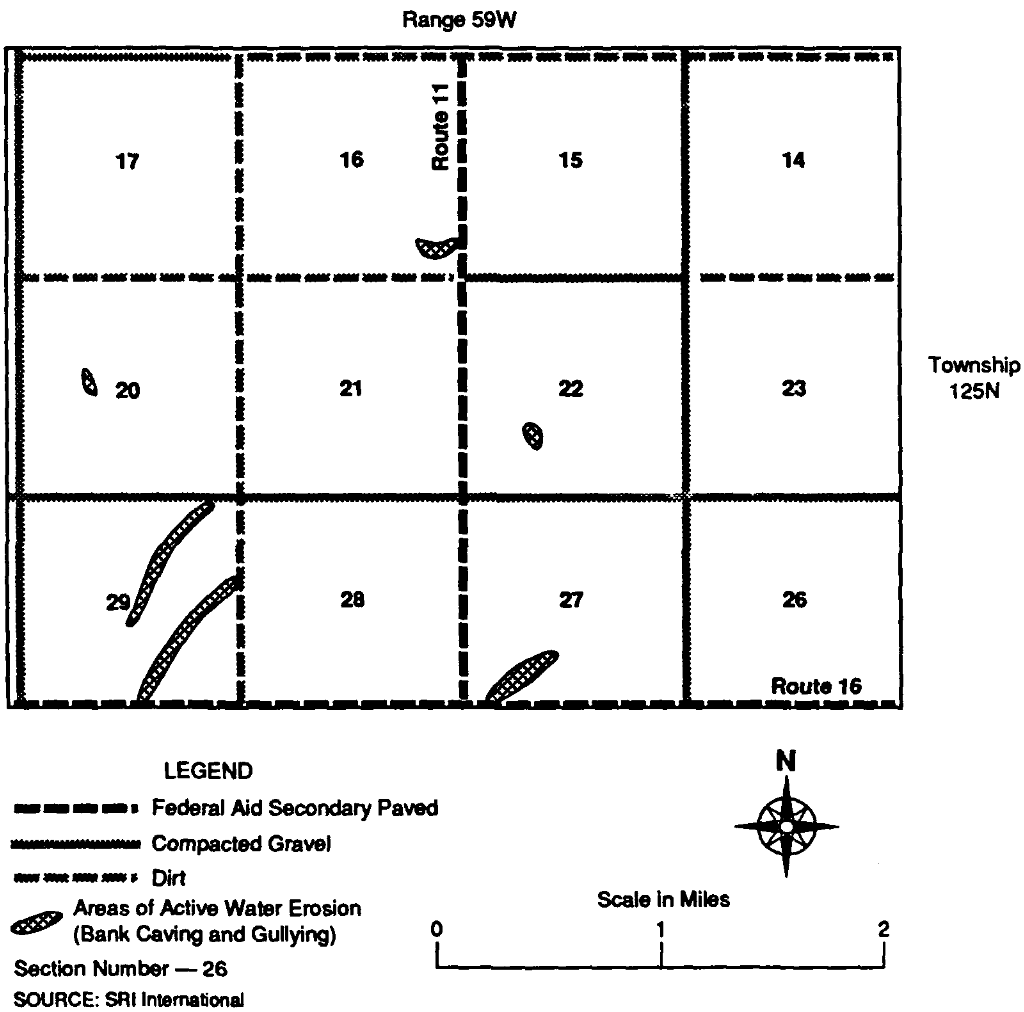


FIGURE 3.1.2 EROSION CONDITIONS AT Tx–S

the granite is directly overlain by glacial and glaco-lacustrine deposits of the Pleistocene Epoch (1.8 million to 10,000 years ago) that range up to 300 ft in thickness and are exposed at the surface. These deposits include lacustrine sand and gravel and lake-modified till of the Erskine Moraine Association. (Hobbs and Goebel, 1982; Minnesota Geological Survey, 1979 and 1972) Rx-E is entirely underlain by sandy glacial lake sediments deposited on beaches of Lake Agassiz or in the shallow near-shore area. Rx-W is underlain on its eastern portion by sand beach sediments and on its western part by lake-modified till that is clayey and includes limestone clasts. (Hobbs and Goebel, 1982)

3.1.2.2 Groundwater

The basement rocks under the receive study area have inadequate porosity and permeability to store significant quantities of water and serve as an aquifer. Small quantities of water may be produced from areas of local faulting and fractures. The glacial deposits overlaying the basement rocks yield water in inverse portion to their clay content. Rx-W is underlain at shallow depth by clayey units, and well yields would be expected to be less than 1 gpm. Glacial till beneath the clayey lacustrine deposits contains sand and gravel and could yield up to 300 gpm. Rx-E is underlain by sandy lake deposits that can support wells yielding up to 150 gpm. No till occurs beneath the sandy lake deposits. (Kanivetsky, 1978 and 1979; Metcalf and Eddy/Holmes and Narver, 1990D)

3.1.2.3 Seismicity

Minnesota is classified as Seismic Zone 1, in which the maximum earthquake intensity is expected to be Modified Mercalli VI. No earthquakes have been recorded with epicenters within 50 mi of the alternative receive sites. The level of seismic risk is exceedingly low. (Reagor, 1981; Stover, 1981)

3.1.2.4 Economic Geology

No areas in Pennington, Polk, or Marshall counties in Minnesota produce metallic minerals or oil or gas. The most important mineral resources are sand and gravel. Lime is also mined in Polk County. (U.S. Department of the Interior, 1986; Lipp, 1987)

3.1.2.5 Soils

The SCS has mapped the soils of the alternative CRS receive sites at both the soil association level (eastern site only) and the soil series level. Rx-E is primarily within the area of the Rollis-Vallers Association, which includes nearly level, poorly drained soils formed from glacial till. A smaller portion of Rx-E includes soils of the Lohnes-Karlstad Association, which are well to moderately well-drained, nearly level to gently sloping soils formed from lacustrine sediments. (Heschke, 1984)

Table 3.1.3 shows the soil series that occur at Rx-E and their properties. The soils of this site are considered highly productive and are of Capability Class II or III for the most part; four of the 13 series are considered Class IV - VI. Severe limitations exist to placement of septic systems on these soils because of soil wetness and ponding of rainwater. Over much of the site, soil is subject to frost action that can damage roads. Drainage is poor over much of the site, and the potential for runoff erosion is generally slight. The Vallers loam, Foldahl fine sandy loam, Syrene fine sandy loam, and Rosewood fine sandy loam, however, are highly prone to soil blowing.

The SCS soil survey for Polk County is being prepared, and information on soil associations is not available. The area of Rx-W, however, has been mapped at the series level, which is more detailed than the association level. Table 3.1.4 lists soil series occurring at Rx-W and their properties. The soils are of Capability Classes II to IV, indicating high possible agricultural productivity. The hazard to structures from shrink-swell behavior is low. Poor drainage and high potential for frost action present severe limitations to construction of septic systems and roads on

Table 3.1.3
PROPERTIES OF SOILS AT RX-E

Soils Series	Capability Class [a]	Shrink-Swell Potential	Limitations: Septic Systems	Limitations: Roads	Drainage	Erosion Potential
Grimstad fine sandy loam	II	Low	Severe[b]	Mod	Good	Mod
Ulen fine sandy loam	III	Low	Severe[b]	Mod	Good	Mod
Vallers loam	II	Low	Severe[b]	Severe[c]	Poor	High[d]
Lohnes loamy coarse sand	IV	Low	Severe[e]	Slight	Good	Mod
Mavie fine sandy loam	III	Low	Severe[b]	Severe[c]	Good	Slight
Foldahl fine sandy loam	II	Low	Severe[b]	Severe[c]	Poor	High[d]
Syrene fine sandy loam	IV	Low	Severe[b]	Mod	Poor	High[d]
Rockwell fine sandy loam	II	Low	Severe[b]	Severe[c]	Poor	Slight
Cathro much	IV	Low	Severe[e]	Severe[c]	Poor	Slight
Roliss loam	II	Low	Severe[b]	Severe[c]	Poor	Slight
Rosewood fine sandy loam	III	Low	Severe[b]	Mod	Poor	High[d]
Hamre muck	III	Low	Severe[f]	Severe[c]	Very poor	Slight
Rosewood fine sandy loam, seepy	VI	Low	Severe[b]	Severe[c]	Very poor	Slight

a Rated on a scale of I to VIII with I being the most productive farmland.
b Limitation due to soil wetness.
c Limitation due to frost action.
d High erosion potential due to susceptibility to soil blowing.
e Limitation due to poor filtration capacity of soil.
f Limitation due to ponding of water on this soil.

Source: Heschke, 1984

Table 3.1.4

PROPERTIES OF SOILS AT RX-W

Soils Series	Capability Class[a]	Shrink-Swell Potential	Limitations		Drainage	Erosion Potential
			Septic Systems[b]	Roads		
Grimstad fine sandy loam	II	Low	Severe	Mod	Good	Mod
Ulen fine sandy loam	III	Low	Severe	Mod	Good	Mod
Hamerly loam	II	Low	Severe	Severe[c]	Good	High[d]
Vallers loam	II	Low	Severe	Severe[c]	Poor	High[d]
Percy loam	II/IV	Mod	Severe	Severe[c]	Poor	Slight
Mavie fine sandy loam	III	Low	Severe	Severe[c]	Poor	Slight
Rockwell fine sandy loam	II	Low	Severe	Severe[c]	Poor	High[d]
Roliss loam	II	Low	Severe	Severe[c]	Poor	Slight
Lohnes loamy sand	IV	Low	Severe [e]	Low	Good	Slight
Vallers-Hamerly loam	II	Low	Severe	Severe[c]	Poor	Slight

a Rated on a scale of I to VIII with I being the most productive farmland.
b Limitation due to soil wetness for all soils except Lohnes loamy sand.
c Limitation due to high potential for frost action.
d High erosion potential because of susceptibility to blowing.
e Limitation due to poor filtration capacity of soil.

Source: Johnson, 1989.

these soils. The soil wetness in many areas would greatly reduce the effectiveness of leach fields. The potential for runoff erosion is slight to moderate, but several series—Hamerly loam, Vallers loam, and the Rockwell fine sandy loam—are highly prone to blowing if vegetative cover is disturbed.

3.1.2.6 Topography and Erosion

Rx-E ranges in elevation from about 975 ft msl along the western boundary to about 1,005 ft msl along the eastern boundary. The site slopes fairly uniformly downward to the west at gradients less than 1-2%. The only substantial relief at the site occurs on a beach ridge located in the eastern portion of the site. That ridge rises about 10 ft above the surrounding terrain and is oriented almost due north-south. There is little evidence of active erosion at the site. A small gully has formed in the north-central portion of Section 19, T154N, R45W, and an abandoned borrow pit in the extreme southeastern corner of Section 29, T154N, R45W has been somewhat eroded by runoff.

Rx-W is located at elevations ranging from 920-940 ft msl and slopes downward fairly uniformly to the west. Slope gradients are less than 1% throughout the site. No features produce significant amounts of relief at the site. The lack of substantial slope gradients minimizes the potential for runoff erosion on site, but small gullies have formed in the northwestern and southeastern quadrants of Section 20, T154N, R46W. Otherwise, there are no signs of active erosion. Some soils at the site are susceptible to wind blowing, but there is no evidence of existing problems due to blowing.

3.1.3 Power Supply

3.1.3.1 Transmit Site

Geology—The power supply corridors under consideration for the CRS transmit sectors are located in Brown, Marshall, and Day counties, South Dakota, and in Sargent County, North

Dakota. The bedrock and surficial geology of these corridors is similar to that described for the transmit sites. At depth, basement crystalline rocks of Pre-Cambrian age (greater than 565 million years ago) occur hundreds to thousands of feet below the ground surface. Those basement rocks are overlain by several hundred ft of gently dipping Tertiary (66 to 2 million years ago) sedimentary layers. The uppermost three units of the Tertiary rocks are the Carlile and Niobrara formations and the Pierre shale. Above the Tertiary sedimentary layers are various glacial and glacial-lake deposits ranging in thickness up to 300 ft. The thickness of the glacial deposits generally increases from southwest to northeast across the powerline study area. In some areas, particularly along Links 1 and 7, the glacial deposits are overlain by recent windblown sands and silts. Recent alluvial deposits also occur along streams, mostly in the southern and southeastern portion of the study area. (Harris, 1987; Koch, 1975; Leap, 1986 and 1988; Bluemle, 1979; and Clayton et al.,1980)

The geology of each link under consideration as a power supply corridor is described below:

Link 1: The uppermost bedrock unit is the Pierre shale which is overlain by less than 50 ft of glacial deposits. The glacial units include lacustrine silts of glacial Lake Dakota, fine eolian sands, and deltaic deposits. The deltaic deposits consist of silt, sand, and gravel and are coarser than the lacustrine silts or eolian sands. The silt and sand deposits are subject to wind erosion as evidenced by the presence of recent eolian deposits. (Leap, 1986)

Link 2: As with Link 1, the uppermost bedrock unit is the Pierre shale which is here overlain by up to 100 ft of glacial deposits, including lacustrine silts of Lake Dakota. Small areas of stagnation till of the Waubay moraine also occur; those deposits are generally clayey with bedrock clasts. A number of streams draining the Prairie des Coteau, which is east of this link, cross the link and have left significant alluvial deposits. (Leap, 1986 and 1988)

Link 3: About 100-150 ft of glacial deposits lay above the Pierre shale, including lacustrine deposits from glacial Lake Dakota and till from the recessional Oaks moraine. The lacustrine units

are composed of clays, silts, sands, and gravels and are generally varved. The Oaks moraine is an unstratified and unsorted deposit. (Koch, 1975)

Link 4: The Pierre shale is the uppermost bedrock layer and is overlain by 50-150 ft of glacial deposits, with the thickest deposit in the northeastern portion of the link. Glacial deposits include lacustrine deposits of Lake Dakota, a ground moraine, and part of the Oaks moraine. The ground moraine consists of clay with some soil, sand, and gravel, and forms gentle to undulating terrain. Alluvium and outcrops of the Pierre shale occur along drainages. (Koch, 1975)

Link 5: Up to 200 ft of glacial deposits overlay the Pierre shale, including lacustrine sediments of Lake Dakota, part of the Oaks moraine, and fine to medium dune sand. The dune topography provides up to 30 ft of elevational relief. (Koch, 1975)

Link 6: The Pierre shale is overlain by up to 200 ft of glacial deposits, including lacustrine sediments and an end moraine. The end moraine is a ridge composed of bouldery drift.

Link 7: The Niobrara and Carlile formations are the uppermost bedrock layers. Glacial deposits range up to 200 ft thick and include till, glacial thrust blocks, and river-eroded till. The glacial deposits are composed of sand, silt, and clay with abundant cobbles and boulders and form a relatively flat surface. Sand dunes and river channel deposits overlay the glacial till consist of fine sand to gravel. Blowouts due to wind erosion are common. (Koch, 1975; Harris, 1987)

Link 8: The uppermost bedrock units are the Niobrara and Carlile formations which are overlain by 100-200 ft of glacial deposits. The glacial units consist of dead-ice moraine and sediments from glacial Lake Dakota. The moraine is composed of clays, silts, and sands with abundant cobbles and boulders. The lacustrine sediments are bedded near-shore silts and sands. Extensive areas of windblown sheets and sand dunes cover the southern portion of this link, and blowouts are common in that area. (Harris, 1987; Bluemle, 1986; Clayton et al., 1980)

Link 9: The uppermost bedrock unit is the Carlile formation that is overlain by 100-300 ft of glacial deposits. The glacial deposits are composed of unsorted and unstratified clays, sands, and

silts with some larger clasts that have been eroded in places by the wave action of Lake Dakota. Glacial lake sediments and end moraine drift are also included. (Bluemle, 1986; Clayton, et al., 1980; Harris, 1987)

Link 10: The Carlile formation bedrock is overlain by 200-300 ft of till, mostly in the form of a dead-ice moraine. The glacial sediment includes clays, silts, and sands with abundant larger clasts. (Bluemle, 1986; Clayton, et al., 1980; Harris, 1987)

Groundwater—The Pre-Cambrian basement rocks of the CRS transmit powerline study area have insufficient porosity and permeability to serve as sources of groundwater. Several aquifers occur within the Cretaceous sedimentary rocks and the glacial deposits of the area and provide large amounts of water.

In North Dakota, the Cretaceous-age Dakota Group, consisting of sandstone to shale, is up to 400 ft thick and produces up to 50 gpm from some wells. The Pierre shale can produce small quantities of water from fractures within the rock; yields are generally less than 5 gpm. Wells ranging from 100-200 ft deep can produce up to 1,500 gpm from glacial deposits, but that yield is variable, and some glacial sediments have very low yields. Water quality is also variable, although in general, the water is highly mineralized. (Armstrong, 1982; North Dakota Geological Survey, 1973)

In South Dakota, the Dakota group is about 900 ft below the ground surface and has yielded up to 200 gpm of water, although the water quality is generally poor. The Pierre shale is generally within 100-200 ft of the ground surface and yields 1-5 gpm of water to wells. Water quality is generally poor with high chloride and sulfate concentrations. The James aquifer underlying portions of Links 2, 3, and 4 draws from buried glacial outwash deposits. Wells drawing from this aquifer are less than 200 ft in depth and can yield up to 500 gpm of water. The main water-quality concern is high salinity. (Leap, 1986 and 1988; Koch, 1975)

Seismicity—North Dakota and South Dakota are in seismic risk Zone 1, which corresponds to a low level of seismic risk. The strongest earthquake with an epicenter recorded within 100 mi

of the CRS transmit-site powerline study area had a Modified Mercalli intensity of VI. An earthquake of that magnitude can cause slight to moderate damage to poorly built structures, but would not be expected to damage well-built structures. (Reagor, 1981A and 1981B; Stover, 1981)

Economic Geology—Section 3.1.1.4 describes economic mineral resources of the South Dakota portion of the study area. There are no known economic deposits or commercial producers of metallic minerals or oil or gas in Sargent County, North Dakota. The Niobrara formation is a potential source of cement rock. Sand and gravel are obtained from glacial deposits in various parts of the county. (North Dakota Geological Survey, 1973)

Soils—The Sargent County, North Dakota, portion of the powerline study area contains the following soil associations: Forman-Aastad, Barnes-Svea, Gardena-Spottswood-Wessington, Gardena-Glyndon, and Valentine-Hecla (See Table 3.1.5). These associations are generally well-drained loamy to sandy soils formed from glacial till or glacial lake sediments. The Forman-Aastad and Barnes-Svea associations have formed from loamy till and are nearly level. The Gardena-Spottswood-Wessington soils have formed from glacial outwash and are underlain by sand and gravel. The Gardena-Glyndon association has formed from silty lake sediment and is moderately well drained. The Valentine and Valentine-Hecla associations have formed in loamy fine sands and include choppy relief up to 40 ft. (Larsen, 1964)

The Marshall County, South Dakota portion of the powerline study area includes the following soil associations: Maddock-Serden, Embden-Hecla-Ulen, Beotia-Great Bend, Harmony-Aberdeen-Exline, Kranzburg, Forman-Poinsett, and Forman-Aastad-Buse. The Maddock-Serden, Embden-Hecla-Ulen, Beotia-Great Bend, and Harmony-Aberdeen-Exline soils have formed from lacustrine silts and sands and from eolian sands that are nearly level, and vary in drainage from poor to excessive. The Kranzburg and Forman-Poinsett soils have formed from glacial till or loess over glacial till and are well drained and level to sloping. The Forman-Aastad-Buse soils are well-drained loamy soils formed from glacial till. (Schultz, 1975)

Table 3.1.5
SOIL ASSOCIATIONS OF POWERLINE CORRIDORS FOR CRS TRANSMIT SITE

Link	Associations
1	(Brown County Not Surveyed at Association Level)
2	Harmony-Aberdeen-Exile (Day County portion not surveyed)
3	Embden-Hecla-Ulen, Beotia-Great Bend, Forman-Poinsett
4	Beotia-Great Bend, Harmony-Aberdeen-Exile, Kranzburg, Forman-Poinsett
5	Maddock-Serden, Embden-Hecla-Ulen
6	Embden-Hecla-Ulen, Beotia-Great Bend
7	Forman-Aastad, Barnes-Svea, Gardena-Spottswood-Wessington
8	Forman-Aastad, Gardena-Glyndon, Vallentine-Hecla
9	Forman-Aastad, Gardena-Glyndon, Beotia-Gread Bend Harmony-Aberdeen-Exile, Forman-Aastad-Buse
10	Forman-Aastad

Source: Shultz, 1975.

Topography and Erosion—The study area for the CRS transmit-site powerline corridors is generally level to gently sloping. Along drainage channels, particularly in the southern and southeastern portion of the study area and where sand dunes and glacial end moraines exist in the northern portion of the study area, tens of feet of relief exist. The highest elevation of the study area is roughly 1,550 ft msl at the eastern boundary, and the lowest is about 1,250 ft msl near the

Forman substation. Slope gradients are generally less than 2%. The topography of each link is described below:

Link 1: Elevations vary from about 1,300-1,310 ft msl, and slope gradients are less than 1%.

Link 2: Elevations vary from about 1,300 ft msl at Tx-S and the Groton substation to about 1,450 ft msl at the extreme southeastern corner. Slope gradients range up to 2%.

Link 3: Elevations range between 1,295-1,310 ft msl, and slope gradients are less than 1%.

Link 4: Elevations range from about 1,300 ft msl near Britton to 1,550 ft msl at the right-angle turn east of Langford. Slope gradients range up to 8% at the southeastern portion of the line.

Link 5: Elevations range from about 1,300-1,360 ft msl. Slope gradients are up to 5%, and sand dunes provide relief up to 30 ft.

Link 6: Elevations range from about 1,300-1,350-ft msl. Slope gradients are less than 5%.

Link 7: Elevations range from about 1,300 ft msl at the southern and the eastern termini of the link to about 1,500 ft msl at the northwestern corner. Slope gradients range up to 5%.

Link 8: Elevations are within a few ft of 1,300 ft msl throughout this link, and slope gradients are less than 1%. Sand dunes provide local topographic relief at the southern portion of the link.

Link 9: Elevations range between 1,250-1,300 ft msl. Slope gradients are below 1%.

Link 10: Elevations range from 1,250-1,300 ft msl, with an upslope to the west at a gradient of less than 1%.

Active erosion in the CRS transmit-site powerline corridors is largely the result of poor land management that allowed rills and gullies or wind-caused blowouts to form. Gullies have occurred at scattered areas as a result of poor drainage control and are most pronounced in the southern and eastern portions of the study area where slope gradients are greatest. Because of the relatively low slope gradients found throughout the corridors, gullies tend to be relatively limited in lateral extent

and depth and are not a significant hazard. Blowouts have occurred in the central portion of the area at the northern portion of Link 1, the southern portions of Link 7 and 8, and throughout Link 5, where lacustrine silts and fine sands are highly prone to wind erosion. Blowouts are a more severe hazard than gullying, and large dune fields have formed along Links 7 and 8 north of Tx-N.

3.1.3.2 Receive Site

Geology—The geology of the powerline corridors for the CRS receive sites is similar to that of Rx-E and Rx-W. Bedrock is Pre-Cambrian granite, and no bedrock of Cambrian through Tertiary age is present. Directly overlying the granite is glacial and glaco-lacustrine sediments of Pleistocene age. Surficial deposits consist of wave-plane glacial till of the Erskine moraine association and lacustrine sand and gravel from glacial Lake Agassiz. The alternative powerline corridors connecting to the Radium, Dakota Junction, and Morris-Owen Substation do not differ significantly in the type or area of surficial deposit present. (Hobbs and Goebel, 1982; Minnesota Geological Survey, 1979)

Groundwater—All of the receive-site powerline corridors are underlain at depth by granitic bedrock, which is not considered an aquifer. The glacial sediments overlying the granite bedrock vary somewhat in composition between the corridors for the eastern and western CRS sites. The powerline corridors connecting to the Dakota Junction and Morris Owen Substation (eastern CRS receive) site are underlain primarily by glacial till that yields less than 1 gpm of water on a sustained basis. The corridor connecting to the Radium Substation (western CRS site) is underlain by clayier lacustrine sediments, which also yield less than 1 gpm of water. Much higher yields of water, up 150 gpm, however, have been reported in the vicinity, probably from wells penetrating buried glacial till below the lacustrine deposits. (Metcalf and Eddy/Holmes and Narver 1990B; Kanivetsky, 1978 and 1979)

Seismicity—As noted above for the alternative receive sites, the receive-site powerline corridors are subject to low levels of seismic activity. The likelihood of an earthquake strong enough to damage powerlines is exceedingly remote.

Soils—Soil associations occurring along the powerline corridor connecting to the Dakota Junction Substation include the Clearwater-Wyandotte-Thiefriver, Lohnes-Karlstad, Rolis-Vallers, Grimstad-Rockwell-Foldahl, and Deerwood-Hamre associations. The Rollis-Vallers and Deerwood-Hamre associations, found in the western portion of the corridor, are fine to medium-textured and poorly drained. Soils of the Grimstad-Rockwell-Foldahl Association are coarser in texture and variable in drainage. In the eastern portion of the corridor, the Lohnes-Karlstad soils are coarse-textured and well drained, whereas the Clearwater-Wyandotte-Thiefriver soils are fine-textured and poorly drained. Soil blowing is a severe hazard for all of these soils except for the Deerwood-Hamre soils. Seasonally, high groundwater occurs throughout much of the corridor, except in areas of the Lohnes-Karlstad Association. The Clearwater-Wyandotte-Thiefriver soils generally have high shrink-swell potential. (Heschke, 1984)

The corridors connecting to the Morris Owen Substation also contain soils of the Clearwater-Wyandotte-Thiefriver, Rollis-Valler, Lohnes-Karlstad, and Deerwood-Hamre associations. In addition, both corridors contain soils of the Rosewood-Ulen-Flaming Association, which are moderately coarse-textured and range from poor to moderately well drained. Soil blowing is a hazard, and the seasonally high groundwater table is a limitation to building.

Soils of the powerline corridor for Rx-W have been mapped at the soil series level; information on soils and their properties is presented in Table 3.1.6. In general, the soils of the area are highly productive, and several of the series meet criteria for prime farmland. The productivity is increased significantly by drainage improvements, as most soils are poorly drained.

Shrink-swell potentials are low to moderate; the major limitations to road construction are frost action, wetness, and low strength. The most significant erosion hazard is wind blowing, to which most soils of the corridor are susceptible. (Johnson, 1989)

Table 3.1.6
SOILS SERIES OF POWER SUPPLY CORRIDOR FOR Rx-W

Soils Series	Capability Class[a]	Shrink-Swell Potential	Limitations: Roads	Limitations: Drainage	Erosion Potential[b]
Borup	II/IV	Low	Severe[c]	Poor	Mod
Grimstad	II	Low	Mod	Poor/mod well	High
Kiltson	I	Low-mod	Severe[c]	Poor/mod well	Mod
Glyndon	II	Low-mod	Severe[c]	Poor/mod well	Mod
Hamerly	II	Mod	Severe[c]	Poor	Mod
Vallers	II/IV	Low-mod	Severe[c]	Poor	Mod
Mavie	III/IV	Low	Severe[c,d]	Poor	High
Poldahl	II/III	Low-mod	Severe[c]	Poor	High
Rockwell	II/IV	Low	Severe[c]	Mod well	Mod
Rollis	II	Low-mod	Severe[c,e]	Poor	Low
Fluvaqents-Haploborolls	N/A	N/A	Severe[d]	Poor	Low
Velva	N/A	N/A	N/A	Poor/mod well	N/A
Kratka	III/IV	Low-mod	Severe[d]	Poor	N/A

Note: N/A = Information not available.

a *Drained/undrained.*
b Hazard for all series due to blowing.
c Limitation due to frost action.
d Limitation due to wetness.
e Limitation due to low strength.

Source: Johnson, 1989.

Topography and Erosion—The topography of each receive-site powerline corridor is described below:

Dakota Junction Substation–Rx-E: Elevations range from about 1,150 ft msl at the eastern portion to about 1,000 ft msl at the western terminus. The ground slopes downward to the west at a relatively uniform gradient of about 0.5-1.0%. At the extreme western portion of the corridor, two glacial beach ridges have relief of 10-20 ft and side slopes with up to 2% gradient.

Morris Owen Substation–Rx-E: Two parallel corridors about 1 mi apart are under consideration. Elevations range from about 1,000-1,130 ft msl. The ground slopes downward to the west at an average gradient of less than 0.5%. Glacial beach ridges at the western portion of the corridors create local relief up to 30 ft with side slope gradients up to 3%. The topography of the alternative corridors is nearly identical.

Radium Substation–Rx-W: Elevations range from 915-930 ft msl with no appreciable longitudinal slope gradient. The only features creating local relief are the channels of the Snake River and its tributaries, which are up to 10 ft deep.

Erosion levels are very low in all receive-site powerline corridors. The area is essentially flat, and runoff is very slow, reducing the potential for water erosion. Wind blowing resulting from poor land management is a more severe hazard . The soils of the three corridors for Rx-E are generally susceptible to blowing if the vegetative cover is destroyed. The only area where blowing is not a hazard is in low-lying portions of Goose Lake Swamp where the clayey soil is usually wet. The soils of the powerline corridor for Rx-W are generally finer-grained and somewhat less prone to wind erosion than those of the Rx-E corridors. (Johnson, 1989)

3.2 HYDROLOGY AND WATER QUALITY

This subsection of the EIS, except for subsection 3.2.3 on the powerline corridors, is based on Technical Study 4, Central Radar System Over-the-Horizon Backscatter Radar Program-Hydrology and Water Quality, prepared by Metcalf & Eddy/Holmes & Narver (1990D).

3.2.1 Transmit Study Area

3.2.1.1 General Surface and Subsurface Hydrology and Water Quality

Tx-N and Tx-S are located within the James River subbasin of the Missouri River basin. The James River, located 8-17 mi west of the sites, flows southward and empties into the Missouri River about 185 mi south of the sites.

No major permanent surface water bodies are present at either transmit CSA. A sampling program for 37 lakes and ponds in Marshall County, South Dakota, was conducted in 1969. That study found levels of total dissolved solids, primarily magnesium, calcium, sulfate, and bicarbonate, of less than 700 milligrams per liter (mg/L), as compared to the South Dakota surface water standard of 1,000 mg/L. Compared to the state pH standard of 6.5-9.0, the pH level of surface water in the county ranged from 8.0-9.2. Dissolved oxygen levels ranged from 1.7-14.3 mg/L; exceedance of the state standard is defined as a concentration less than or equal to 5.0 mg/L.

The major aquifers underlying Tx-N and Tx-S are the James aquifer which occurs within glacial drift and the Dakota aquifer which occurs within Tertiary marine sedimentary rocks. At Tx-N, located on the boundary of the James aquifer, the water level is 2-111 ft below the surface. Recharge is primarily through percolation of surface rainfall and snowmelt, with secondary recharge from the subsurface in Brown and possibly Day counties. The predominant flow direction of groundwater is toward the east. Tx-N and vicinity are considered important recharge areas because of the high permeability of surface sediments. Water of the aquifer is sodium,

sulfate, and bicarbonate type. Chloride concentrations measured in 1975 ranged from 8-152 mg/L, which is below the South Dakota standard of 250 mg/l for drinking water.

The Dakota aquifer occurs in interbedded sandstone and shales more than 350 ft below the surface and underlies both alternative transmit site layouts. Recharge is thought to be from other aquifers in the Black Hills, Rocky Mountains, or Central South Dakota; no local recharge has been identified. Groundwater movement is from east to west in response to heavy pumping from the aquifer. The water from the aquifer near the study area is of the sodium sulfate type. Chloride concentrations are 210-400 mg/L, and fluoride concentrations are 2.8-9.3 mg/L, as compared with South Dakota state standards of 250 mg/L for chloride and 2.4 mg/L for fluoride concentrations of drinkable groundwater. Existing groundwater wells in the vicinity of the two transmit preliminary site layouts yield 2-25 gpm.

3.2.1.2 Tx-N

Tx-N slopes to the southwest except for the eastern portions of Sections 32 and 5 and the southeastern portion of Section 29, which slope to the south. The site is adjacent to the continental divide that separates the Red River of the North and the Missouri River basins; therefore, it receives very little overland flow from off-site areas. Surface runoff flows overland to the southwest and south in response to the ground slope. Numerous small depressions (prairie potholes) collect and store runoff throughout the site. Runoff not trapped by those potholes flows to the Portage-Detroit Drainage Ditch southwest of the site. That ditch discharges into the Crow Creek Drainage Ditch, which is a tributary of the James River.

The Federal Emergency Management Agency (FEMA) has not prepared flood hazard maps for this area; therefore, the 100-year flood zone is not known. No areas at the site, however, are known to flood. The Crow Creek drainage ditch flooded in 1989, but floodwaters did not affect Tx-N.

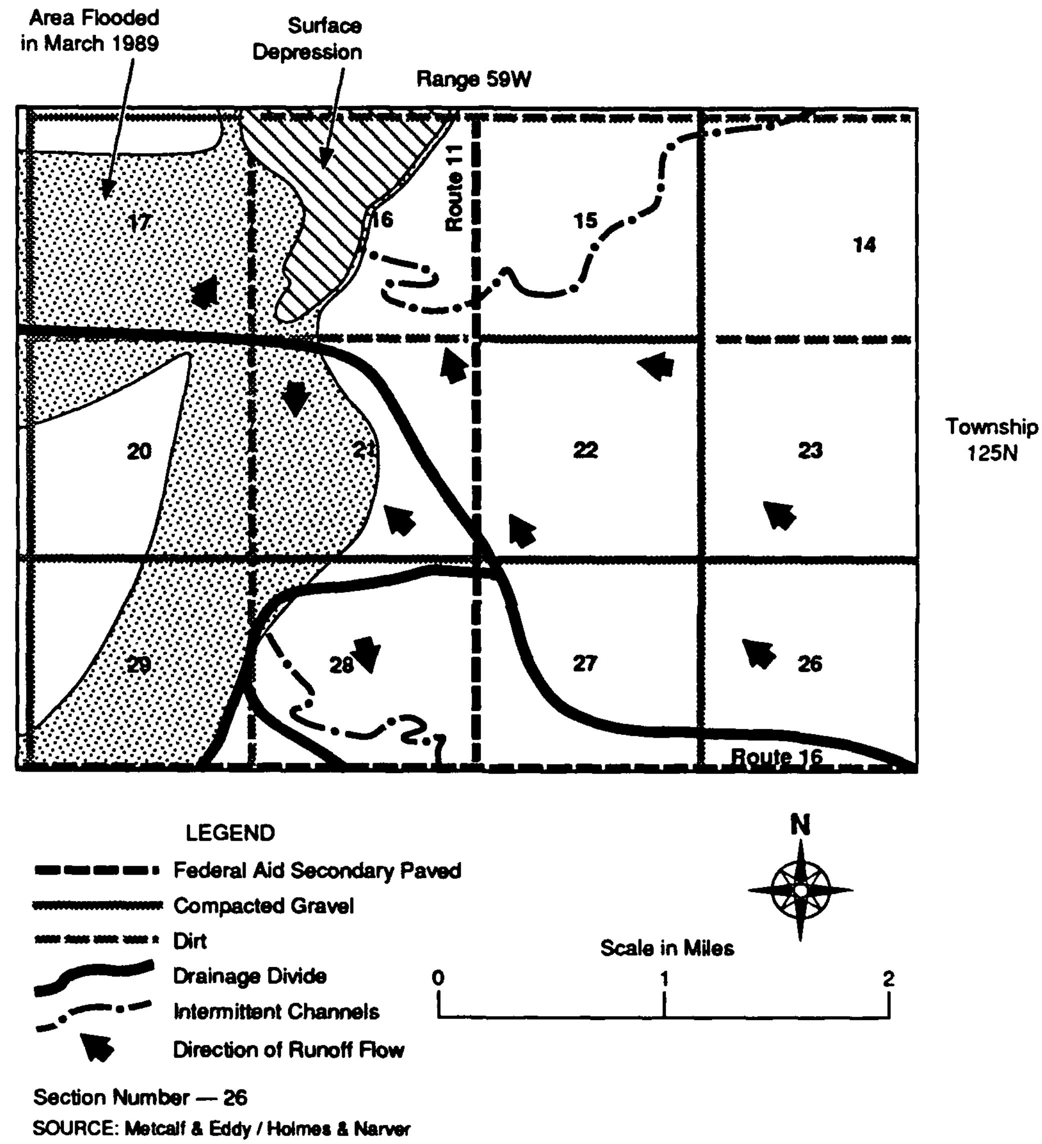
3.2.1.3 Tx-S

Tx-S receives off-site runoff from three directions. An extensive network of roadside swales and ditches at the site transports runoff from off site and on site to creeks and drainages of the area.

An unnamed stream flows onto the site at its northeastern corner and drains a watershed extending into the Coteau des Prairies with an area of 60 mi^2. That watershed extends 17 mi east of Tx-S and includes a portion of the Coteau des Prairies, part of the western escarpment of the Coteau, and farmlands around Langford. Runoff also flows westward overl[illegible]d across the eastern site boundary via natural channels and ditches to the southern portion of Section 16, T125N, R59W, where a natural depression extending northward from the site for several miles collects local runoff. That depression serves as a detention basin for runoff from portions of the site located in Sections 14-17, 22-23, and 26-27 and 60 mi^2 of land to the east of the site. The depression would overflow southward into Antelope and Mud Creeks, which are tributaries of the James River (see Figure 3.2.1), but because of the depression's large size of about 4 mi^2, overflow is not expected.

Surface runoff from portions of Sections 27 and 28, T125N, R59W, drains into an unnamed creek at the southwestern portion of the CSA. The creek is a tributary of Antelope Creek, which discharges into Mud Creek, a tributary of the James River. Portions of sections 20-21 and 28-29 also drain by overland flow to low-lying areas south of the site, which are tributary to Antelope Creek.

FEMA has not mapped flood hazard areas at Tx-S. Parts of this site flooded as a result of a warm spell that caused extensive melting of snow when the ground and channels were still frozen during March 1989. The low-lying depression at the northern part of the site collected water, causing flooding over much of the western portion of the CSA. In addition, the tributary channel to Antelope Creek in the southwestern portion of the CSA overflowed its banks, flooding adjacent areas. Figure 3.2.1 shows areas that were flooded during March 1989.



SOURCE: Metcalf & Eddy / Holmes & Narver

FIGURE 3.2.1 DRAINAGE PATTERNS AND FLOOD HAZARDS AT Tx–S

3.2.2 Receive Study Area

3.2.2.1 General Surface and Subsurface Hydrology and Water Quality

Rx-E and Rx-W are within the watershed of the Red River of the North, which flows northward along the boundary between North Dakota and Minnesota and into Manitoba, Canada. The preliminary site layouts are located roughly 25-35 mi east of that river and are within the Middle River/Snake River Watershed District. The Snake River, located about 3 mi north of the Rx-W, flows westward and is a tributary of the Red River of the North.

No permanent surface water bodies are located at either Rx-W or Rx-E, although ditches and low-lying areas collect water at various times of the year. Surface water in the general vicinity of the sites is generally low in total dissolved solids (less than 500 mg/L) and is considered suitable for domestic and agricultural purposes. Purification is required for use of surface waters for drinking water supply.

Groundwater occurs within lenses of coarser material within the glacial and glacial lake sediments at the two alternative receive sites. The fine-grained lacustrine sediments have extremely low yields of water, whereas the coarser lacustrine silts, sands, and gravel have somewhat higher yields, although still generally less than 5 gpm. The beach ridge areas, including the Campbell Beach Ridge adjacent to the eastern receive site, have generated yields up to 20 gpm. At greater depth, glacial till beneath the lacustrine sediments contain aquifers yielding up to 300 gpm. Bedrock at the site is impervious and does not contain aquifers.

Groundwater in the vicinity of Rx-E and Rx-W typically has average chloride levels of 50 mg/L, average hardness of about 300 mg/L, average sulfate concentrations of 200 mg/L, and iron concentrations of more than 1 mg/L. A state study of pesticide contamination of groundwater in Minnesota conducted recently found no contamination of the eight wells in the vicinity

investigated. The study determined that the low recharge potential, fine texture of the soil and subsoil, and high organic content of the soil limit the potential for pesticide contamination.

3.2.2.2 Rx-E

The eastern boundary of Rx-E is located on the elevated Campbell Beach Ridge, in Pennington County, Minnesota, which forms a drainage divide. To the east of the divide, runoff flows directly into Judicial Ditch 25. To the west of the divide, including the site, runoff flows overland in a westerly direction and is collected by an unnamed intermittent stream that flows to the southwest. That channel connects to Judicial Ditch 25, which continues westward until it discharges into a tributary of the Snake River.

According to FEMA maps, the Rx-E is not within a 100-year flood zone. The Red River of the North has been prone to severe flooding, especially when frozen reaches of the river inhibit flow of spring snowmelt water. Because the river flows northward, downstream reaches can be frozen at the same time that upstream areas of the watershed are experiencing snowmelt conditions. The river has flooded eight times since 1950, with the largest flood occurring in 1969. Peak flow of the Snake River reached 4,300 cubic ft per second (cfs), compared with a channel capacity of 1,400 cfs, causing extensive damage along the river. However, no flooding was reported at the site.

3.2.2.3 Rx-W

Rx-W is nearly flat, and storm runoff generally follows the ground surface gradient from east to west across the site. A branch of Judicial Ditch 25 begins at the northern portion of the Rx-W on the boundary between Sections 10 and 15 of T154N, R46W, and turns northward at the northwestern corner of Section 16 to flow off site. A second unnamed ditch originates at the northeastern corner of Section 19 and also collects overland flow and discharge from roadside ditches. This second ditch connects to Judicial Ditch 25; thus, all runoff from the site eventually flows into Judicial Ditch 25 and then into the Snake River.

The flooding potential at Rx-W is the same as at Rx-E. Although the Red River of the North and its tributary, the Snake River, have flooded many times in the past as noted above, that flooding has not affected the site. Rx-W is not within a FEMA 100-year flood zone, and flood hazards are minimal.

3.2.3 Power Supply

3.2.3.1 Transmit Site

The power supply study area for the CRS transmit sites includes portions of both the Missouri River and the Red River of the North drainage basins. Most of the study area, including all of Links 1-5 and southern portions of Links 6-9, drains toward the southwest to the James River, which is a tributary of the Missouri River. The James River, located 8-17 miles west of the CRS transmit CSAs, flows southward through eastern Dickey County, North Dakota, and eastern Brown County, South Dakota, and eventually discharges into the Missouri River about 185 mi south of the transmit study area.

The northeastern portion of the power supply study area, including all of Links 9-10 and portions of Links 6-8, is within the Red River of the North basin. The Wild Rice River, located 18 mi northeast of Tx-N, flows northeastward across Sargent County, North Dakota. It joins the Red River of the North about 7 mi south of Fargo, North Dakota, or about 95 mi northeast of Tx-N. The Red River of the North flows northward, forming the state border between Minnesota and North Dakota, and into Manitoba, Canada. Water from the Red River of the North eventually discharges into Hudson Bay.

Drainage patterns for each powerline link are described below:

Link 1: The southern part of this link drains into the main channel and tributaries of Mud Creek, which flows southwestward across the link and joins the James River about 14 mi to the

southwest. The northern part of the link drains into tributary channels of the Crow Creek Drainage Ditch, which discharges into the James River about 5 mi west of the link.

Link 2: The southern part of this link drains into Mud Creek and tributaries. The northern part drains into Antelope Creek, which is itself a tributary of Mud Creek.

Link 3: A small portion of this link drains into a large closed depression adjacent to Tx-S. The majority of the link drains into Crow Creek, which flows westward across the link and empties into the Crow Creek Drainage Ditch.

Link 4: A number of streams with headwaters in the Coteau des Prairies flow westward across this link and collect surface runoff. In the southern part of the link, those streams are tributaries of Antelope Creek. In the northern portion of the link, the streams are tributaries of Crow Creek.

Link 5: This link drains into ditches which flow southward into Crow Creek, about 5 mi south of the link.

Link 6: The western part of this link drains into the Dayton-Stena and the Dayton-Crow Creek ditches which flow southward to Crow Creek. The eastern portion of the link contains numerous small depressions. Runoff not collected by those depressions flows to the Wild Rice Creek, about 4 mi to the northeast and a tributary of the Wild Rice River.

Link 7: The extreme southern part of this link drains into the Dayton-Stena and connected ditches, which empty into Crow Creek and the Crow Creek Drainage Ditch. The remainder of this link is drained by man-made channels connecting to Meszaros Slough, which is a tributary of the Wild Rice River.

Link 8: The southern part of this link drains into the Dayton-Stena ditch, which flows southward to Crow Creek. The central and northern portions of the link drain into the Wild Rice River, whose headwaters rise near the midpoint of the link.

Link 9: Wild Rice Creek, a tributary of the Wild Rice River, whose headwaters are in the Coteau des Prairies southeast of this link, flows northward across the link. The Wild Rice River also flows eastward across the central part of this link. Many small closed depressions collect and retain runoff from this link.

Link 10: This link contains many closed depressions. Through-flowing runoff flows to Crooked Creek, located about 2 mi northeast of the link. Crooked Creek flows eastward and empties into an unnamed lake in central Sargent County, North Dakota.

The transmit-site powerline corridors contain a number of areas with high wetlands concentrations. Based on National Wetland Inventory maps prepared by USFWS, the majority are palustrine emergent wetlands. A small portion are palustrine scrub/shrub and forested, lacustrine, or riverine. In general, the concentrations of wetlands increases from south to north across the powerline study area. About 5% or less of the area of Links 1-4 and 6 in Brown and Marshall counties, South Dakota are wetlands. Links 5 and 7-9 in northern Brown and Marshall counties and Sargent County, North Dakota, contain about 6-9% wetlands. Link 10 in Sargent County contains the highest concentration of wetlands, 18% of its land area (see Table 3.2.1).

3.2.3.2 Receive Site

The powerline corridors for the CRS receive sites are within the Red River of the North basin. Wetland areas for each link were calculated from NWI maps (See Table 3.2.1). The percentage of wetland area included ranges from 3.3-5.6%. The most common type of wetland is palustrine emergent; sizable areas of palustrine scrub/shrub and riverine wetlands are also present.

The easternmost 6 mi of the two corridors connecting the Morris Owen Substation to Rx-E drain into ditches that flow southward to the Red Lake River. The western portions of those corridors drain into channels connecting to Branch 3 of Judicial Ditch 25, which itself empties into the Black River south of the corridors. The Black River is a tributary of the Red Lake River,

Table 3.2.1
WETLAND AREAS OF CRS TRANSMIT-SITE AND RECEIVE-SITE POWERLINE CORRIDORS

Link	Palustrine Emergent (ac)	Palustrine Forested (ac)	Other [a] (ac)	Total Wetland Acreage	% of Link/ Corridor Area
Transmit Site Corridors					
1	1,744	41	93	1,878	4.7
2	1,073	2	114	1,189	3.4
3	836	13	15	864	4.1
4	911	3	145	1,059	3.1
5	302	0	1	303	7.5
6	306	0	0	306	2.9
7	2,992	8	370	3,370	8.6
8	1,439	0	64	1,503	8.5
9	2,615	14	138	2,767	9.1
10	808	0	42	850	18.0
Receive Site Corridors[b,c]					
Rx-E/DJ	33	0	19	52	3.3
Rx-E/MON	21	1	29	51	5.6
Rx-E/MOS	28	1	17	46	4.9
Rx-W	8	0	2	10	1.5

a - Other includes lacustrine; riverine; and palustrine scrub/shrub, unconsolidated bottom, and aquatic bottom wetlands.

b - Rx-E/DJ = Rx-East to Dakota Junction; Rx-E/MON = Rx-E to Morris-Owen, northern corridor; Rx-E/MOS = Rx-E to Morris Owen, southern corridor; Rx-W = Rx-W to Radium Substation.

c - Wetland acreages are for portions of corridors outside CSA only. Additional wetland acreages occurring within CSA are Rx-E/DJ - 1 acre, Rx-E/MON-37 acres, and Rx-E/MOS-11 acres.

SOURCE: Hammon, Jensen, Wallen, and Associates, 1990.

which flows westward to its confluence with the Red River of the North at Grand Forks, North Dakota. Thus, those two corridors in their entirety drain to the Red River of the North via the Red Lake River.

The corridor connecting the Dakota Junction Substation to Rx-E crosses the Thief River about 1.5 mi west of the substation. The eastern portion of that corridor drains into the Thief River, a tributary of the Red Lake River. The western portion of the corridor, beginning about 4 mi west of the Substation, drains into channels connecting to Branch 3 of Judicial Ditch 25, which also empties into the Red Lake River via the Black River.

The powerline corridor connecting the Radium Substation to Rx-W crosses both the main branch and the South Branch of the Snake River. The Snake River flows westward and northwestward to its confluence with the Red River of the North. Runoff from the corridor flows either directly into those two branches of the Snake River or into man-made channels that are tributaries of the Snake River.

3.3 AIR QUALITY

3.3.1 Regulatory Context

3.3.1.1 Federal

Pursuant to the Federal Clean Air Act of 1970 (42 U.S.C. 7401-7642), the U.S. Environmental Protection Agency (EPA) has established ambient concentration standards and emission standards for air pollutants. Federal ambient concentration standards [National Ambient Air Quality Standards (NAAQS)] have been set for six "criteria" pollutants: ozone (O_3), carbon monoxide (CO), respirable suspended particulate matter having an aerodynamic diameter smaller than or equal to 10 microns (μ) (PM_{10}), nitrogen dioxide (NO_2), lead (Pb), and sulfur dioxide (SO_2). The 1977 Clean Air Act Amendments (Public Law 91-95, 91 Stat. 685, 1977) required

each state to identify areas that did not meet the NAAQS ("nonattainment areas") and to devise a State Implementation Plan (SIP), subject to EPA approval, to attain the NAAQS within those areas.

3.3.1.2 South Dakota

The South Dakota Department of Water and Natural Resources (SDDWNR) coordinates and oversees the activities of that state on air quality matters. It is responsible for incorporating "nonattainment plans" into the SIP and for operating the state's ambient air monitoring program. The SDDWNR has established ambient air quality standards for the state and has adopted a number of rules and regulations, including emissions requirements, for a variety of stationary sources. For proposed projects in the state that would be major new sources of air pollution, the SDDWNR has established permit and review procedures. South Dakota does not have state requirements for emissions from mobile sources. No local governmental agencies within South Dakota regulate air quality, and no additional requirements, regulations, or ordinances regarding air quality have been set for the counties in which the CRS transmit site is proposed. Ambient air quality standards established by SDDWNR are shown in Table 3.3.1.

3.3.1.3 Minnesota

The Minnesota Pollution Control Agency (MPCA) coordinates and oversees air quality matters within the state. This agency is responsible for incorporating Minnesota's "nonattainment plans" into the SIP and for operating the state's ambient air monitoring program. The MPCA has established ambient air quality standards for the state of Minnesota and has adopted a number of rules and regulations, including emissions requirements, for a variety of stationary sources. For proposed projects in the state that would be major new sources of pollution, MPCA has established permit and review procedures. MPCA has opacity requirements for mobile sources, but otherwise has no emission requirements for mobile sources. No local governmental agencies within Minnesota regulate air quality, and no additional requirements, regulations, or ordinances have

Table 3.3.1
AIR QUALITY STANDARDS

Pollutant	Concentration ($\mu g/m^3$) NAAQS[a]	SDDWNR	MPCA
Respirable particulate matter (PM_{10})	50[b] 150[c]	Same as NAAQS	None
Total suspended particulates (TSP)	Discontinued July 1, 1987	60[d] 250[f]	75[d,e] 260[f,g]
Sulfur dioxide (SO_2)	80[b] 365[f,g]	Same as NAAQS and 1300[h]	Same as NAAQS and 1300[h,j]
Nitrogen dioxide (NO_2)	100[b]	Same as NAAQS and 250[f]	Same as NAAQS
Ozone (O_3)	235[k]	160[i]	Same as NAAQS
Carbon monoxide (CO)	10,000[l] 40,000[i]	Same as NAAQS	10,000[l] 35,000[i]
Lead (Pb)	1.5[m]	None	None
Hydrocarbons	None	None	160[n]
Hydrogen sulfide (H_2S)	None	None	70[o]

Note: $\mu g/m^3$ = microgram per cubic meter

- a Primary standards to protect of human health.
- b Annual arithmetic mean.
- c Maximum 24-hr concentration not to be exceeded more than once a year.
- d Annual geometric mean.
- e Minnesota secondary standard for TSP: 60 $\mu g/m^{3,d}$, and 150 $ug/m^{3,f}$.
- f Maximum 24-hr concentration not to be exceeded more than once per year.
- g A secondary standard, set for human welfare, exists for sulfur dioxide. It is 1,300 ug/m^3 maximum 3-hr concentration not to be exceeded more than once per year.
- h Maximum 3-hr concentration not to be exceeded more than once per year.
- i Maximum 1-hr concentration not to be exceeded more than once per year.
- j The Minnesota secondary standard is 60[b], 365[c], and 915 $\mu g/m^{3,h}$ in some regions, and 1,300 $\mu g/m^{3,h}$ in other regions.
- k Maximum hourly average concentration not to be exceeded more than once per year.
- l Maximum 8-hr concentration not to be exceeded more than once per year.
- m Maximum arithmetic mean averaged over a calendar quarter.
- n Maximum 3-hr concentration (6:00 a.m. to 9:00 a.m.) not to be exceeded more than once per year.
- o 30-min average concentration, not to be exceeded over two times per year.

Source: U.S. Environmental Protection Agency, South Dakota Department of Water and Natural Resources, and Minnesota Pollution Control Agency.

been set regarding air quality for the counties in which the receive site is proposed. Ambient air quality standards established by MPCA are shown in Table 3.3.1.

3.3.2 Meteorology

The primary factors determining local air quality are the locations of air pollutant sources and the amounts of pollutants emitted. Meteorological and topographical conditions, however, are also important. Atmospheric stability, wind speed, wind direction, and air temperature gradients in conjunction with the physical features of the landscape determine the movement and dispersal of air pollutants. With frequent and rapid weather changes occurring during all seasons of the year and the flat terrain, the topography and meteorology of the CRS sites aid the dispersal of air pollutants. Both the transmit and receive study areas typically experience a continental climate marked by wide temperature variations and distinct seasons. Frequent and rapid weather changes occur during all seasons of the year. Snowfall is occasionally heavy in winter, and winter storms produce gale force winds that fill the air with fine, wind-driven snow termed ground blizzards by area residents. Spring is a short transitional period, the shortest of the four distinct seasons, and one marked by very rapid weather changes. Precipitation increases markedly in the spring.

For the South Dakota transmit study area, 42% of the total annual precipitation is normally recorded in the 3-month period from April through June. Thunderstorms occur frequently during spring and summer, and hailstorms are most frequent in midsummer. Summer days are typically warm to hot, with a maximum of sunshine, and summer nights are cool to quite cold. Autumn has mild days, cool nights, ample sunshine, and declining amounts of precipitation.

Existing weather information is limited for both the transmit and receive study areas. Recent wind speed and direction monitoring information for the Thief River Falls study area is available for Grand Forks AFB, about 30 mi away; older data are available from Thief River Falls Airport records. Wind speed and direction information for the South Dakota transmit study area is available for Aberdeen, South Dakota, about 35 mi away.

Mean vertical mixing heights for both the transmit and receive sites are shown in Table 3.3.2. Seasonal morning mixing heights, with the exception of spring for the transmit study area and summer for the receive study area, are comparable. Afternoon mixing heights are considerable lower in winter than in other seasons of the year.

Table 3.3.2
MEAN MIXING HEIGHTS FOR CRS STUDY AREAS
(Meters)

	Transmit Study Area (South Dakota)		Receive Study Area (Minnesota)	
Season	Morning	Afternoon	Morning	Afternoon
Winter	380	600	400	600
Spring	500	1,600	420	1,600
Summer	340	1,800	310	1,800
Fall	400	1,300	400	1,300

Source: Holzworth, 1972.

The absence of large bodies of water in the regions of the alternative transmit and receive study areas contributes to rapid temperature fluctuations. Temperatures may range from above 100°F in summer to as low as -50°F in winter. Annual mean temperatures are about 36°F for the Minnesota receive study area, where subzero temperatures can occur from October to April, and about 43°F for the South Dakota transmit study area, where subzero temperatures may occur as early as November, but generally are not recorded until mid-December.

3.3.2.1 Wind Speeds at the Transmit Study Area

A 14-year collection of meteorological wind measurements from Aberdeen between 1964 and 1978 shows winds to be frequent, variable, and moderately strong. An estimated 35% of the

winds are between 6.7 and 11.3 miles per hour (mph), and about 79% are between 6.7 and 20.1 mph. Winds are below 6.7 mph about 13% of the time and below 4.8 mph only about 3% of the time. Winds exceed 20.1 mph about 11% of the time. The average wind speed is 12.1 mph in winter, 13.6 mph in spring, 11.0 mph in summer, and 11.6 mph in autumn.

Winds in the CRS transmit study area come from northerly and southerly directions throughout the year. In January, about 33% of the winds come from northwest to north with an average speed of 15.7 mph; about 15% of winds are from the south, the next preferred direction, with an average speed of 10.2 mph. Calm conditions occur approximately 3% of the time. In April, about 14% of the winds in the transmit study area are from due north at 14.8 mph, about 17% come from south-southeast to south at an average speed of 14.1 mph average speed, and calm conditions occur about 2% of the time. July is typical of the summer pattern, with southerly winds slightly stronger and more frequent than northerly winds. About 23% of the July winds come from south-southeast to south at 11.6 mph and about 10% from the north at 10.1 mph. Calm conditions prevail about 3% of the time. In October, about 31% of the winds come from northwest to north at an average speed of 14.2 mph, about 26% come from the south-southeast to south sectors at an average 11.8 mph, and calm conditions prevail about 2% of the time.

3.3.2.2 Wind Speeds at the Receive Study Area

The most recent wind direction data relevant to the receive study area in northwestern Minnesota is from Grand Forks AFB, in North Dakota, about 25 mi from the study area. Wind data from the 10-year period 1972-1982 show a predominance for both northerly and southerly winds each month of the year. Easterly winds are the least frequent. In January, about 57% of the winds at the receive sites come rather uniformly from the sectors between west and north at an average speed of 12.8 mph, about 16% of which are from due north at an average speed of 9.4 mph. Additionally, about 11% of the January winds are from the south at an average speed of 10.9 mph, and calm conditions occur about 7% of the time. In April, about 28% of the winds at the receive study area are from north-northeast to north at 12.3 mph average speed, about 15%

from south-southeast to south at 11.7 mph, and calm winds are present about 6% of the time. In July and August, winds are less strong; about 11% are from the north at about 7.7 mph, about 9-11% are from the south at 8.5-9.0 mph, and calm conditions occur about 9% of the time.

Older wind data from the Thief River Falls Airport show the same general pattern as the data from Grand Forks AFB, except that the northerly winds are more frequently from the northwest, and winds are calm a greater percentage of the time. These data show calm conditions occurring between a low of about 8% in April and a high of about 24% in July.

3.3.3 Existing Air Quality

3.3.3.1 Transmit Study Area

Marshall and Brown counties and all of South Dakota, with the exception of the Rapid City area near the Black Hills, comply with of NAAQS and SDDWNR standards. This attainment has been documented with a network of monitoring stations established by the state of South Dakota pursuant to EPA regulations. The monitoring network is in place at six locations in the state that are either urban or the site of tourism (such as Mt. Rushmore and Wind Cave National Parks). No monitoring in rural areas of the state is planned, but it is reasonable to assume that pollutant concentrations in rural areas are less than those measured by the monitoring network.

The monitoring data show that South Dakota's most prevalent air pollutant is PM_{10}, typical sources of which are fuel combustion (ashes and soot), fugitive dust (wind, mechanical erosion of local soil, and construction), industrial processes (metals, fibers, etc.), and photochemical reactions (complex chain reactions between sunlight and gaseous pollutants). PM_{10} Concentrations measured in the state are shown in Table 3.3.3. Only low concentrations of NO_2 were found, and monitoring for this pollutant was discontinued as of December 31, 1986, because of unavailability of audit materials and concentrations too low for collocation samplers to measure properly. South Dakota is not currently monitoring for O_3 either because the state does not have a large volume of concentrated sources that contribute to O_3 formation.

Table 3.3.3
MEASURED SOUTH DAKOTA PM_{10} CONCENTRATIONS

Parameter	Concentrations ($\mu g/m^3$) Brookings	Sioux Falls	Rapid City[a]
Annual arithmetic mean	30.2	23.1	37.8 26.6 30.2
24-hr maximum	107.5	51.6	80.9 125.2 121.8

a There are three PM_{10} monitoring sites in Rapid City.

Source: South Dakota Department of Water and Natural Resources, 1989.

No emission sources other than grain elevators are located in the CRS transmit study area. The closest significant emission sources are two industrial plants in Aberdeen, about 35 mi southwest of the site. South Dakota defines "significant" as an emission rate equaling or exceeding any of the following standards: 100 tons per year (t/yr) for carbon monoxide; 40 t/yr for nitrogen oxides; 40 t/yr for sulfur dioxide; 25 t/yr for particulate matter; 40 t/yr for volatile organic compounds; and 0.5 t/yr for lead.

3.3.3.2 Receive Study Area

Polk, Pennington, and Marshall counties comply with NAAQS and MPCA standards. MPCA has not seen a need to monitor pollutants in the Thief River Falls area. The closest TSP monitoring data are from the White Earth Indian Reservation, 50-90 mi south-southwest of the site. The monitoring program has been operating at six sites since 1984 . These data show that the MPCA 24-hr primary standard was not exceeded more than once annually, in compliance with the

standard, but the secondary standard was exceeded twice annually at one location in 1988, the only violation. Annual mean TSP concentrations in the White Earth area range from 15.4-26.5 $\mu g/m^3$ for the entire time of monitoring, well within the MPCA primary standard of 75 $\mu g/m^3$.

Significant emission sources closest to the study area are located in Angus, Warren, Thief River Falls, St. Hilaire, and Newfolden. MPCA requires permitting of all sources that emit 25 t/yr or more of a single criterion pollutant. Area emission sources are listed in Table 3.3.4.

Table 3.3.4
STATIONARY EMISSIONS SOURCES NEAR CRS RECEIVE STUDY AREA

Source	Location	Distance from CRS Sites	Emissions (t/yr) TSP	CO	NO_2	HC
Great Lakes Gas Trans. Co.	Thief River Falls	12 mi E[a]	3	26	65	1
Farmers Co-op Grain & Seed Elevators	Thief River Falls	12 mi E[a]	24	0	0	0
St. Hilaire Co-op Elevators	St. Hilaire	14 mi SE[a]	17	0	0	0
Midwestern Gas Trans. Co.	Angus	6 mi SW[b]	0	17	133	4
Harvest States Co-op Elevators	Warren	8 mi NW[b]	47	0	0	0
Newfolden Co-op Elevator Assn.	Newfolden	14 mi NE[a]	43	0	0	0

a Rx-E.
b Rx-W.

Source: Minnesota Pollution Control Agency.

3.4 NOISE

3.4.1 Overview

Sound intensity is customarily measured in units named decibels (dB). The standard measurement procedure is to electronically process the mixture of frequencies contained in the measured sound to make them similar to the way that the human ear hears them. A sound measurement modified in this way has units termed "A-weighted decibels," or dBA.

Because environmental noise levels normally fluctuate with time, a time-averaged noise level, in dBA, is often used to characterize the acoustic environment at a given location. One time-averaging scheme results in an index of environmental noise known as the "energy equivalent noise level," or L_{eq}, that calculates an equivalent steady-state sound level for any given measurement period. The "day-night equivalent noise level," or L_{dn}, incorporates a 10-dBA penalty for noise occurring between 10:00 p.m. and 7:00 a.m. This descriptor, or a similar one known as the Community Noise Equivalent Level (CNEL), is normally used in the community noise compatibility guidelines that prescribe acoustical environments acceptable for different types of land use. Table 3.4.1 shows noise levels of some typical activities.

3.4.2 Existing Noise Levels and Sources

The CRS transmit and receive study areas are located in remote rural areas. The noise environments are caused by vehicular traffic on local rural roads, aircraft, agricultural, activities on the adjacent farms, and natural sounds generated by wind and wildlife. Because this EIS was prepared during the winter when agricultural activity at both the transmit and receive study areas in South Dakota and Minnesota is at a low, on-site noise measurements were not made. Instead, the existing noise environment is estimated from noise measurements at other sites in rural and remote areas (see Table 3.4.2). Projects "A" and "B" were on remote but hilly locations unlike the flat

country that is typical of the CRS sites. These hilly locations, however, do provide a lower bound on the noise levels that might be expected in remote areas. Project "C" resembled the terrain and location of the CRS sites, except that it was located in a more populous area. On the basis of these measurements, and the reference value given in Table 3.4.1 for rural areas, a noise level of about 45 dBA, L_{dn}, is estimated as the existing noise level at the alternative CRS transmit and receive CSAs.

Table 3.4.1
EXAMPLES OF NOISE LEVELS

Noise Level (dBA)[a]	Example of Source
140[b]	Jet engine at 75 ft
130	Limit of amplified speech
120	Maximum vocal effort
110	Jet takeoff at 2,000 ft
100	Shouting in ear
90	Pneumatic drill at 50 ft
80	Freight train at 50 ft
70	Freeway traffic at 250 ft
60	Hospital incinerator at 50 ft
50	Quiet conversation at 10 ft
40	Rural environment at night
30	Soft whisper
20	Broadcasting studio
10[c]	Barely audible noise

a Based on sound pressure.
b Threshold of pain.
c Threshold of hearing

Source: Honour, 1979; Cunniff, 1979; and ESA, 1990

Table 3.4.2
MEASURED RURAL NOISE LEVELS

Project	Setting of Measurement	Measured Noise Levels
A	Western side of San Joaquin Valley, California, on eastern slopes of Diablo Range. Bordered by Interstate Hwy 5 on eastern side.	20-25 dBA in sheltered valleys 35-40 dBA on rural access roads 30-40 dBA at higher elevations with commercial aircraft overflights at operating altitudes
B	In California, bounded by, but removed from major freeways, in windy, hilly terrain composed of several ridges separating flat terrain on either side.	35-45 dBA, daytime L_{eq} (primarily from wind)
C	California rural community on local road and on valley floor near adjacent hills	46-49 dBA hourly average from 7:00 p.m. to 2:00 a.m

Source: ESA, 1990

Traffic noise in the areas of the proposed sites is minimal, as would be expected of a rural area. The local road network consists primarily of gravel, dirt, and paved county roads, with average daily traffic (ADT) counts typically less than 100. Only one paved state trunk highway, Minnesota Route 1, is near any of the sites; it passes about 2 mi from Rx-W and about 1 mi from Rx-E. For this highway, the ADT is less than 700 in the vicinity of the receive sites.

3.4.3 Noise Standards

Certain land uses are recognized as more sensitive than others to high noise levels; thus, for planning purposes, federal, state, and local agencies often establish compatibility guidelines. These guidelines generally regard residential land use as the most noise-sensitive of the general

land uses. Federal and state guidelines provide a basis for local agencies to tailor noise and compatibility standards that reflect the expectations and desires of a local community. EPA identifies 55 dBA, L_{dn}, as the maximum acceptable noise level for residential land use. State or local guidelines for noise standards have not been established for the transmit study area in South Dakota.

Concerning the receive study area, Minnesota has established limiting levels of sound consistent with speech, sleep, annoyance, and hearing conversation requirements within areas grouped according to land activities. Minnesota uses the L_{10} noise descriptor, defined as the sound level in dBA that is exceeded 10% of the time in a 1-hour survey, and the L_{50} descriptor, defined as the sound level in dBA that is exceeded 50% of the time in a 1-hr survey. For household units, including farmhouses, the noise level is not to be greater than 60 dBA, $L_{50,}$ or 65 dBA, $L_{10,}$ during the day. At night, the noise level is not to exceed 50 dBA, $L_{50,}$ or 55 dBA, L_{10}. For contract construction and governmental services, Minnesota sets the maximum permissible noise levels, day or night, as 65 dBA, $L_{50,}$ and 70 dBA, L_{10}. For agricultural land use, the maximum allowed levels, day or night, are 70 dBA, L_{50} and 75 dBA, L_{10}. The Minnesota standards do not, by themselves, identify the limiting levels of impulsive noise needed for the preservation of public health and welfare, and they place no limit on occasional loud noises of short duration.

Residential units, schools, hospitals, and parks are land uses that are considered to be more sensitive to changes in ambient noise levels than commercial, industrial, or certain governmental land uses.

Only isolated farmhouses exist near any of the sites, except for Carpenters Corner, a small rural settlement slightly more than 2 mi from Rx-E. Based on USGS maps, no farmhouses are closer than about 0.5 mi from the alternative preliminary layouts. Table 3.4.3 shows the number of rural dwellings near the preliminary site layouts.

Table 3.4.3
PROXIMITY OF RURAL DWELLINGS TO PLANNED CRS FACILITIES

Alternative Site	Number Between 0.5 and 1.0 mi	Number Between 1.0 and 2.0 mi
Tx-N	2	5
Tx-S	3	11
Rx-E	3	7
Rx-W	8	11

Source: ESA, 1990

Near the project sites, three wildlife species are potentially sensitive to noise: moose, sharp-tailed grouse, and prairie chicken. Moose are sensitive in the spring, during the week or so just prior to calving. Moose are fairly common near the Thief River Falls receive study area, but only occasional, isolated animals would be expected at the South Dakota transmit study area. Both types of birds are sensitive to prolonged noise during the spring, when they are using their "booming" or "strutting" grounds, and both species remain sensitive throughout the spring. The strutting grounds are used year after year; one is at the northern edge of Tx-N, two within Tx-N itself, and one in the area of planned construction. Rx-W has a booming ground about 2 mi from planned construction areas; two such grounds are located near Rx-E, one at the preliminary site layout, and one more than 3 mi away.

3.5 ELECTROMAGNETIC ENVIRONMENT

This section and Section 4.6 are based on a report entitled Analysis of the Potential for Electromagnetic Interference and Radiofrequency and Powerline Field Bioeffects, Central Radar System, Over-the-Horizon Backscatter Radar Program, prepared by SRI International (1990B).

3.5.1 Electromagnetic Noise

The major sources of electromagnetic noise in the radio frequency (RF) range include thunderstorms, galaxies in outer space, and man-made sources. Lightning discharges emit RF radiation that can propagate around the world. Atmospheric radio noise primarily occurs at frequencies below 20 megahertz (MHz). Above 20 MHz, atmospheric noise deceases with increasing frequency and is generally exceeded by galactic radio noise. Galactic noise itself, however, is usually exceeded by man-made noise, which is strongest in urban areas. Sources of man-made noise include high-voltage power lines, automobile ignition systems, electrical motors, and fluorescent lights. Figure 3.5.1 shows seasonal and diurnal changes in radio noise at a frequency of 6 MHz for the central United States.

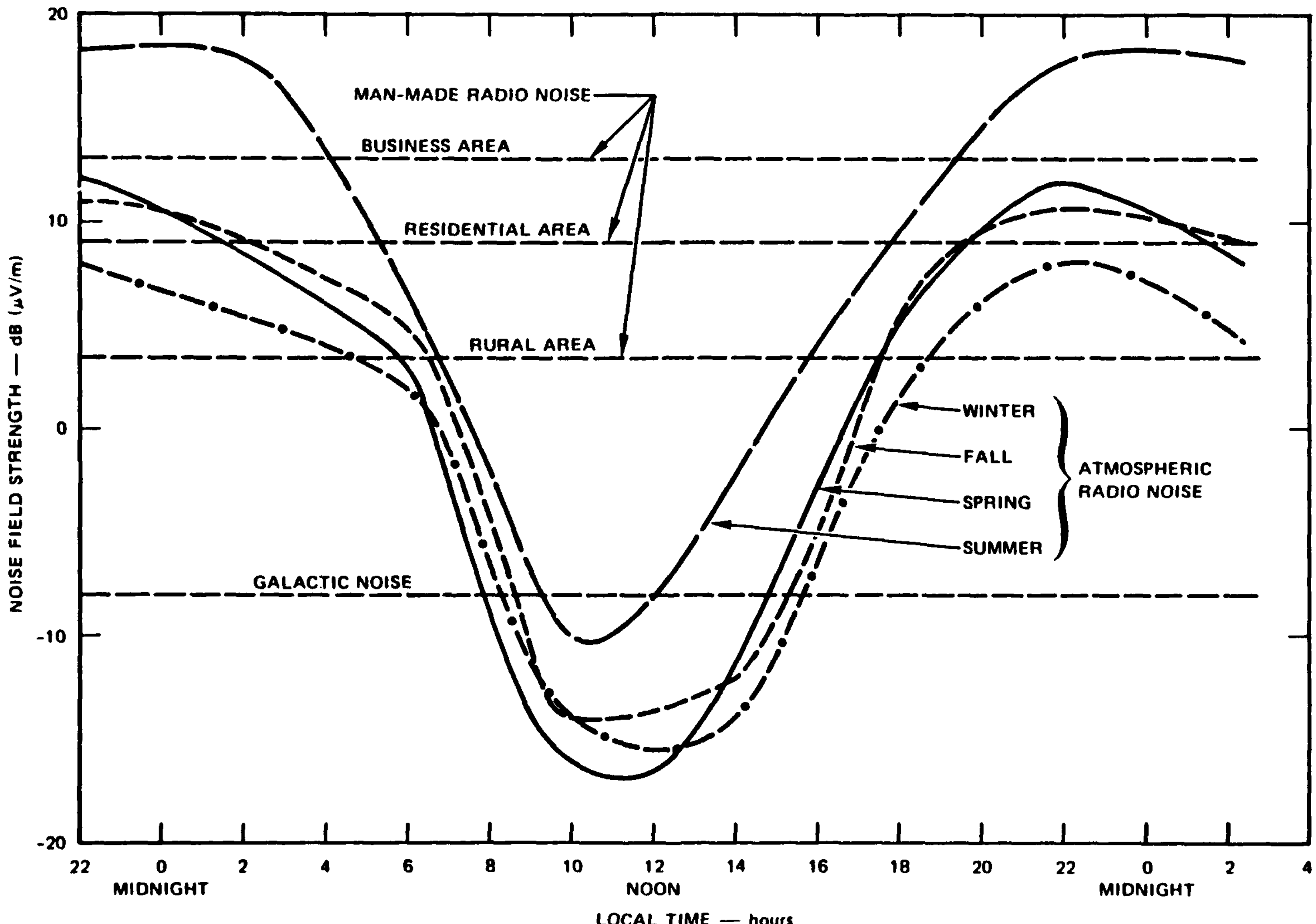
3.5.2 Transmit Study Area

Many frequency bands within the 5-28 MHz range of CRS are assigned to other users. These bands are generally used for air and marine communications, emergency warning systems, and distress calling. Table 3.5.1 shows allocated frequencies within the 5-28 MHz band.

The three bands reserved worldwide for use by the Amateur Radio Service include the 20-m band at 14.0-14.35 MHz, the 15-m band at 21.0-21.45 MHz, and the 10-m band at 28.0-29.7 MHz. The 40-m band at 7.0-7.3 MHz is used by amateur radio users in North and South America, but is allocated to broadcast radio in the rest of the world. At frequencies below 30 MHz, radio signals bounce off the ionosphere and can propagate around the world.

The U.S. Army Corps of Engineers operates about 20 fixed point-to-point communications links with power levels of 100 W in the vicinity of the CRS transmit study area. Within the region, the FCC has authorized about 40 other stations to transmit in the 5-28-MHz band.

Very high-frequency (VHF) television channels (channels 2 through 13) occupy two separate portions of the spectrum between 54 MHz and 216 MHz; the ultrahigh frequency (UHF) channels



SOURCE: SRI International.

FIGURE 3.5.1 RADIO NOISE ESTIMATES FOR CENTRAL U.S. AT 6 MHz (6 kHz Bandwidth)

Table 3.5.1
DISTRESS, CALLING, AND GUARDED FREQUENCIES

Frequency (MHz)	Allocated Services
5.000 ± 0.005	Standard frequency
5.320 ± 0.005	International Ice Patrol
5.680 ± 0.020	Search and Rescue (SAR) control--Atlantic and Pacific
5.6814 ± 0.020	SAR control--Atlantic and Pacific
6.204 ± 0.020	SAR control--Atlantic and Pacific
6.2054 ± 0.020	SAR control--Atlantic and Pacific
6.273 ± 0.010	Aircraft communication to Maritime Mobile Stations
7.5084 ± 0.020	Hurricane warning net
7.530 ± 0.020	Emergency net--Atlantic and Pacific Area
8.364 ± 0.020	SAR control--Atlantic and Pacific
8.502 ± 0.005	International Ice Patrol
8.7564 ± 0.005	International Ice Patrol
10.000 ± 0.005	Standard frequency
11.515 ± 0.020	Emergency net--Atlantic Area
12.150 ± 0.020	Emergency net--Atlantic Area
12.546 ± 0.010	Aircraft communication to Maritime Mobile Stations
12.750 ± 0.005	International Ice Patrol
14.993 ± 0.005	Mobile distress and calling
15.000 ± 0.010	Standard frequency
16.728 ± 0.010	Aircraft communication to Maritime Mobile Stations
18.1975 ± 0.020	Emergency net--Atlantic Area
18.7225 ± 0.020	Emergency net--Pacific Area
19.993 ± 0.005	Mobile distress and calling standard frequency
20.000 ± 0.005	Standard frequency
20.007 ± 0.020	SAR control--astronauts and space vehicles
22.245 ± 0.010	Aircraft communication to Maritime Mobile Stations
25.000 ± 0.005	Standard frequency

Note: Bandwidths are representative.

Source: SRI International

(channels 14 through 69) occupy the continuous spectrum between 470 MHz and 806 MHz. In addition, those living in remote areas that are served poorly by broadcast television stations receive television directly from geostationary satellite transmission in the 3.7- to 4.2-gigahertz (GHz) band using privately owned earth stations. The region in the vicinity of the CRS transmit study area receives fewer television signals than metropolitan areas. Television viewers in the vicinity of the

CRS transmit study area obtain their strongest signals from KDLO (Channel 3) and from KABY (Channel 9); the study area is close to the Grade A contours (includes area over which 70% of televisions receive acceptable reception 90% of the time) of both of these stations. Although no other stations include the study area within their Grade B contours (area over which 50% of television receive acceptable reception—about 110 mi), some viewers possibly would receive adequate signals from the more distant stations.

Station KABY is a satellite of station KSFY, and KDLO is a satellite of KELO, both in Sioux Falls, South Dakota. Presumably, the satellite stations carry the same programs as the "parent" station; if so, residents of the Amherst area have no reason to receive the signals radiated from Sioux Falls.

Station KTTW (Channel 17) in Sioux Falls has an authorized power of 20 kW and an antenna height of 209 ft. Its coverage area is small, and it seems unlikely that it delivers usable signals to the Amherst area, even if a high-gain antenna on a tall mast is used for reception.

Station KDLT (Channel 5) transmits 100 kW from an antenna 1,565 ft high about 6.5 mi south of Salem, South Dakota (a few miles west of Sioux Falls). The Grade B coverage circle for this station has an estimated radius of 75 mi, and residents in the Amherst area are approximately 150 mi from this transmitter. Even with these advantages over station KTTW, KDLT is unlikely to provide useful signals to the Amherst area.

The CRS transmit study area is near the corner of Marshall, Brown, and Day counties; Sargent and Dickey counties are nearby. The number of television households in these counties, is given in Table 3.5.2. A large proportion of the television households in Brown County are clustered in and near Aberdeen, which is 25-35 mi southwest of the alternative CRS transmit sites. Thus, the number of television sets near the CRS study area is smaller than the totals given in Table 3.5.2.

Table 3.5.2
NUMBER OF TELEVISIONS IN COUNTIES NEAR AMHERST, SOUTH DAKOTA

County /State	Number of Households	Number of TV Households
Brown, SD	14,500	14,400
Day, SD	3,000	3,000
Dickey, ND	2,500	2,400
Marshall, SD	2,000	1,900
Sargent, ND	2,000	2,000

Source: Television Digest Inc., 1983

Several airborne communication and navigation systems use RF transmissions to assist air traffic control. Aircraft within line-of-sight of ground stations use VHF frequencies, some of which are in the 118-132-MHz band, for air-to-ground communications. In addition, FAA maintains a number of radio-operated air navigation aids. VHF omnirange (VOR) transmitting stations operate in the 108-128-MHz band. Distance measuring equipment (DME), operating in the 960-1,215-MHz band enables an aircraft to determine its distance from ground-based transmitters. Tactical Air Navigation Systems (TACANS) are used for distance measuring by military aircraft and operate in the same band as DME. When a VOR and a TACAN are collocated, it is called a VORTAC; four VORTACs are located within 120 mi of the CRS transmit study area. Often, VORs and DMEs are collocated; three VOR/DMEs are located within 120 mi of the CRS transmit study area. Nondirectional beacons (NDBs) also assist in air navigation; seven NDBs are located within 120 mi of the CRS transmit study area.

3.5.3 Receive Study Area

The CRS receive sectors would receive signals reflected from the surveillance area and would transmit very low power signals to communicate with the operations center at Grand Forks AFB. This precludes the possibility of electromagnetic interference (EMI) resulting from the CRS receive

sectors. For that reason, the electromagnetic environment need not be described for the receive study area.

3.6 BIOTIC RESOURCES

This section of the EIS discusses biotic resources at the alternative CRS transmit and receive sites. It is based on the six technical studies prepared by Metcalf & Eddy/Holmes & Narver (1990E, 1990F, 1990G, 1990H, 1990I, and 1990J).

3.6.1 Transmit Study Area

3.6.1.1 Vegetation

Prairies historically covered the transmit study area. Tall-grass prairie covered the eastern portion, wheatgrass-bluestem-needlegrass and mixed-grass prairie occurred in the western portion, and sandhills prairie occurred in the northern section. Today, the vegetation of the study area is primarily cropland (75%), grassland (17%), wetland (6%), and deciduous woodland (2%). Croplands dominate the southern three-fourths of the study area, and grasslands dominate the northern fourth. Major crops are spring wheat, flax, corn, oats, barley, alfalfa, sunflowers, and sorghum.

Prime farmlands and farmlands of statewide importance make up 65% of the study area: 46% are prime farmlands and 19% are lands of state importance. The Farmland Protection Policy Act of 1981 established four categories of environmentally sensitive agricultural land: prime farmland, unique farmland, farmland of statewide importance, and farmland of unique importance. The SCS defines prime farmland as land that has the soil quality, growing season, and moisture supply needed to economically produce sustained high yields of crops. Designated prime farmland need not be in current agricultural use, but the land must be available for crop production. That criterion excludes developed land or land under water. Farmland of statewide importance is defined by appropriate state agencies. At the northern CSA, less than 4% of the land is designated prime

farmland (including land that could be prime farmland if drained) and none has been designated land of statewide importance. At the southern CSA, 63% of the land is designated prime farmland (including land that could be prime farmland if drained) and 23% has been designated farmland of statewide importance.

Northern CSA—The northern transmit CSA is within the Hecla Sandhills, South Dakota, an area of undulating topography with excessively drained, sandy soils with wetlands in localized depressions. The current vegetation is predominantly upland grasslands (77%) with moderate amounts of wetland (14%) and small areas of cropland (9%). The grasslands consist of native rangeland that covers 62% of the CSA and grassland with widely spaced shrubs (open shrub grassland) that covers an additional 15%. Woodlands consist primarily of planted shelter belts and small woodlots and account for about 1% of the area. Wetlands are abundant in the central portion of the CSA. The CSA also contains an 80-acre parcel designated as a native prairie. This is the only known location of prairie loosestrife in South Dakota, and is also one of four or five known sites for alpine rush and meadowsweet.

Southern CSA—The vegetation at the southern transmit CSA is: 91% cropland (including 13% that is farmed wetlands), 5% grasslands, 3% unfarmed wetlands, and 1% woodlands. Large tracts of cropland occupy most of the CSA including 81% of the wetlands, with small parcels of grassland scattered among the cultivated fields and unfarmed wetlands. Unfarmed wetlands occur primarily in the eastern and central portions of the CSA. The western portion is cultivated in years of acceptably low water levels, but is readily flooded in wet years. No native vegetation of special importance is present.

3.6.1.2 Wetlands

Wetlands are a valuable resource that provide ecological and economic benefits. They furnish water and habitat for waterfowl and other wildlife and water for crops and livestock. Wetlands also provide protection against flood damage, replenish groundwater, and maintain water quality by filtering nutrients, wastes, and sediments from water. In recent years, wetlands have received

increasing attention. This has resulted in efforts to preserve wetlands such as the North American Waterfowl Management Plan being implemented by the USFWS and the Canadian Wildlife Service. (Metcalf & Eddy/Holmes & Narver, 1990F)

Wetlands, primarily emergent-type, cover 5,790 acres or 6% of the entire CRS transmit study area. Emergent vegetation covers (or would cover in the absence of farming) 91% of the wetlands; 6% is emergent wetland with patches of open water; 1% is covered by trees and shrubs; and 2% is open water without vascular plants. The emergent vegetation is comprised primarily of sedges, rushes, cattails, bulrushes, big bluestem, prairie cordgrass, burweed, asters, goldenrod, and pondweed.

The extent and duration of flooding and the quality of water within CSA wetlands are not known. Generally, wetlands in the region that lose water to the groundwater are only temporarily or seasonally flooded and have the least saline water with (<3 g/L dissolved solids). Wetlands that receive groundwater generally are semipermanent to permanent and have more saline waters (>10 g/L dissolved solids). Wetlands that both receive water from and lose water to the groundwater are intermediate with respect to water quality and duration of inundation.

Wildlife that depend on or heavily use wetlands in the northern plains include dabbling ducks, diving ducks, deer, muskrats, beaver, pheasants, red fox, mink, raccoon, minnows, frogs, salamanders, and various invertebrates, including crayfish. Numerous waterfowl species depend heavily on wetlands during overwintering, spring migration, breeding, and molting seasons. Although the prairie pothole region accounts for only 10 percent of the total waterfowl breeding areas in the continental United States, it accounts for an estimated 50% of all ducklings raised each year. At least 41 percent of the North American population of dabbling ducks rely on these wetlands for breeding habitat. (Metcalf & Eddy/Holmes & Narver, 1990F and 1990H)

Studies have indicated that dabbling ducks such as the mallard and pintail prefer the temporarily and seasonally flooded wetlands because they are usually the earliest to thaw and warm up. Other species such as the diving ducks tend to use the semipermanent and permanent wetlands

to coincide with their later arrival and the wetlands' later availability of invertebrate food sources. *In addition, diving ducks, including the canvasback* and redhead, nest either over or near open water; therefore, the larger wetlands are more suitable for their needs. (Metcalf & Eddy/Holmes & Narver, 1990F and 1990H)

Streams and ponds providing habitat for wholly aquatic species cover 1% or less of the total CRS transmit study area and are absent from the CSAs. Surface drainage ditches and the Renzienhausen Slough comprise most of the aquatic resource in the study area. The principal creeks are Crow Creek, which crosses the northern portion of the study area and is not classified by South Dakota Department of Water and Natural Resources (SDDWNR) as a fisheries resource, and Mud Creek, southwest of the study area, which is classified by SDDWNR as a warmwater, marginal fishery. The larger streams may support benthic invertebrates and northern pike, walleye, crappie, and bass, but the smaller ditches probably support only invertebrates and minnows.

Northern CSA—Wetlands cover 1,068 acres (14%) of the northern transmit CSA. Most of the 731 wetlands are small; the average sizes are 1 acre for temporary and 2 acres for seasonal wetlands. About 16% of all wetlands are temporarily flooded, 74% are seasonally flooded, and 10% are flooded throughout the growing season (semipermanently flooded) in most years. Emergent vegetation covers 1,004 acres (97%) of all wetlands. None of the acreage is shrub- or tree-dominated. No aquatic resources capable of supporting fish are present. The typical wetland is in an isolated watershed and is dominated by native-prairie vegetation. These wetlands generally assist in recharge of groundwater aquifers. However, in late spring when high groundwater conditions occur, groundwater is discharged to the wetlands, lengthening their duration.

Southern CSA—One-hundred and ninety separate wetlands cover 1,191 acres (16%) of the southern CRS transmit CSA. One palustrine emergent wetland covers 640 acres and the other wetlands are small, isolated potholes. About 88% of all wetlands in the CSA are temporarily flooded, 10% are seasonally flooded, and less than 2% are semipermanently flooded; none of the wetlands is permanently flooded. Emergent-type wetlands account for 1,049 acres (88%) of all

these remnants are present, they may contain one or more of the four plant species of special

wetlands; none of the wetlands are shrub- or tree-dominated. Most of the temporary wetlands are farmed when conditions permit. No aquatic habitat capable of supporting fish is present. The impermeable soil at this CSA limits groundwater recharge from the wetlands. The 640-acre wetland provides flood-storage capacity and when flooded the area supports large numbers of migrating waterfowl.

3.6.1.3 Mammals

The mammals discussed in this section are species selected on the basis of field surveys and consultation with the USFWS and the South Dakota Department of Game, Fish and Parks (SDDGFP). Other, smaller mammals are addressed briefly because their large populations and ubiquitous distributions make significant impacts on their populations improbable and because their low economic importance makes economic impacts from any changes in these populations equally improbable.

Northern CSA—White-tailed deer, pronghorn, and various small furbearers are known or expected to occur in the northern transmit CSA, but not in consistently high numbers. Densities of the white-tailed deer population in the CSA are roughly 1-4 per mi^2 during the winter and probably are somewhat lower during the summer. Deer in South Dakota typically inhabit woodlands or marshes supporting thick emergent vegetation, such as cattails and bulrushes, that provide important winter habitat. Woodlands and marshes together cover an estimated 14% of the CSA. The most important winter concentration area in or near the CSA is Renzienhausen Slough, which is about 3 mi south.

Densities of pronghorn in the CSA are probably low throughout the year. They have not historically inhabited the study area, and most that occur in the region are found to the east of the transmit study area. Suitable pronghorn habitat typically contains vegetation comprising 40-60% grass, 10-30% forbs, and 5-20% shrubs, with a permanent water source. Portions of the native grasslands in the CSA could support pronghorn, but the absence of wetlands with permanent open

water reduces the probability of a large population of pronghorn in the area. Two herds were seen in the CSA in 1989.

Small furbearers in the study area include coyote, badger, jackrabbit, striped skunk, red fox, weasel, raccoon, and probably muskrat. The absolute number of these animals in the CSA is probably low, however, because they are mostly small predators with home ranges on the scale of 1-40 mi^2, or even more. Somewhat greater numbers of herbivores such as the muskrat and jackrabbit, or omnivores such as the raccoon and striped skunk, may occur.

Southern CSA—The abundance of agricultural land in the southern CRS transmit CSA could form a food source for deer throughout the year. White-tail deer populations in the CSA, however, probably exhibit the opposite of the pattern of seasonal abundance in the northern CSA because winter cover is sparse, and the number of deer is probably lower in the winter than in the summer.

Small furbearers are probably uncommon in the southern section of the CSA because its wetlands are farmed and because of the lack of vegetation types most suitable for the small wetland mammals on which these furbearers feed in whole or in part. The agricultural lands themselves support some wildlife, but not as well as the native wetlands.

3.6.1.4 Birds

Bird Populations—Major migration corridors for diving and dabbling ducks, geese, and tundra swans cross the CRS transmit study area. Other species groups such as passerines, shorebirds, and raptors also pass through, but their number and migration patterns are generally not well documented. The transmit site study area is within the James River Valley, a major breeding area for ducks, in which up to 1,000,000 pairs of waterfowl may breed each year. Several state and federal wildlife areas are near the study area. The closest, Renzienhausen Slough Game Production Area, is 3 mi south of the northern CSA. Sand Lake National Wildlife Refuge, 8 mi west of the transmit study area, is a major staging area for the Central Flyway and is

especially important for snow geese. Peak goose populations at the refuge typically range from 75,000-400,000 birds in the spring and from 55,000-225,000 birds in the fall. Peak duck populations range from 30,000-350,000 birds in the spring and from 60,000-300,000 birds in the fall. Mean monthly populations of at least 13 species of birds are greater than 5,000 in the spring, and seven species have fall mean monthly populations greater than 15,000. Annual use days for geese and coots are in the range of 3-5 million.

Bird populations observed in the CRS transmit study area during the 1989 spring and fall migrations were similar to historic population levels. An estimated 2 million birds were seen in the northern CSA, and 3.2 million birds were seen in the southern CSA. Most of these were geese, ducks, and blackbirds (see Table 3.6.1), but a total of 202 species were seen in the transmit study area during the four seasons of observation—157 species during the spring and 164 during the fall. However, the numbers seen during each spring and fall migration were lower. Maxima of 96 species were observed at the northern CSA and 105 at the southern CSA, both in spring 1989. However, 1989 was a year of exceptional flooding at the southern CSA, and the differences between the CSAs probably would be less in normal years.

Annual Migration Periods—Spring migration through the CRS transmit study area occurs from March through early June. Raptors, winter finches, and corvids (jays and crows) begin migrating in early March and are typically the first migrants seen. Waterfowl typically migrate during late March and April. Most species of water birds migrate during the second half of April and the first half of May, although gulls and terns may migrate as early as late March. Most shorebirds and most insectivorous passerines migrate late, mainly in May and early June.

Fall migration in the transmit area is more protracted for most species. Some species of shorebirds and passerines begin to migrate south as early as late July and early August. Waterbirds and raptors generally migrate during September and the first half of October, with waterfowl generally migrating from late September into early to mid-November. Winter finches and some other passerine species may persist through the end of November.

Table 3.6.1
NUMBER OF BIRDS OBSERVED DURING DAYLIGHT HOURS AT THE CRS TRANSMIT CSAs DURING SPRING AND FALL 1989 MIGRATIONS

	Northern CSA	Southern CSA
Waterfowl	1,760,000	2,900,000
Geese	1,320,000	2,540,000
Ducks	211,000	199,000
Swans	110	630
Raptors	930	1,440
Shorebirds	720	6,420
Sandhill Cranes	420	630
Waterbirds	7,000	88,000
Gamebirds	100	70
Passerines	201,000	194,000
Blackbirds	161,000	87,000

Source: Metcalf & Eddy/Holmes & Narver, 1990H.

Spring migrants typically appear several days to a week earlier at the transmit study area than at the receive study area. The converse is true in the fall.

Migration Rates—In the CRS transmit study area, only three groups of birds had average daytime migration rates in 1989 that were greater than one bird per hour. Waterfowl had average

migration rates of 830-2,270, passerines of 15-216, and waterbirds of 2-75. All other groups had average daytime migration rates below one bird per hour. Average rates were 0-0.5 birds per hour for sandhill cranes, 0.1-5 birds per hour for shorebirds, 0.01-0.10 birds per hour for game birds, and 0.2-1.3 birds per hour for raptors.

Peak daytime migration rates in 1989 were 11,700-71,700 birds per hour for waterfowl, 200-7,700 birds per hour for passerines, 19-1,290 birds per hour for water birds, 2.2-8.4 birds per hour for raptors, 0-11 birds per hour for sandhill cranes, 1.4-57 birds per hour for shorebirds, and 0.2-1.3 birds per hour for game birds.

Peak night and evening migration rates in the CRS transmit study area were also variable, but roughly correspond to daytime patterns. However, the radars used for night-time measurements could distinguish only numbers of targets (flocks), not numbers of birds or species, so detailed comparison cannot be made. The nocturnal data cannot be interpreted in the same manner as the diurnal data, but they indicate that large numbers of birds move through the study area at night, with peak rates of nocturnal movement generally occurring on the dates when diurnal waterfowl and passerine movements peaked. The surveillance radar used for night-time observations included a long-range setting (3 nmi) and a short-range setting (0.75 nmi). Peak migration rates observed with the long-range radar setting were 59-245 targets per hour, but most average rates were less than 50 targets per hour. Peak rates observed with the short-range radar ranged from 287-750 targets per hour, but average rates were generally below 150 targets per hour in the northern CSA and below 300 targets per hour in the southern CSA on most nights. Mean rates at night ranged from 13-28 targets per hour with the long-range radar, and from 65-231 with the short -range radar.

Daily Flight Times—Diurnal (day) migrants in the transmit study area include eagles, hawks, falcons, harriers, vultures, sandhill cranes, pelicans, and some species of passerines, such as swallows, blackbirds, larks, jays, crows, and doves. Nocturnal (night) migrants, species that migrate almost exclusively by night, include rails, coots, and most passerines. Groups that may

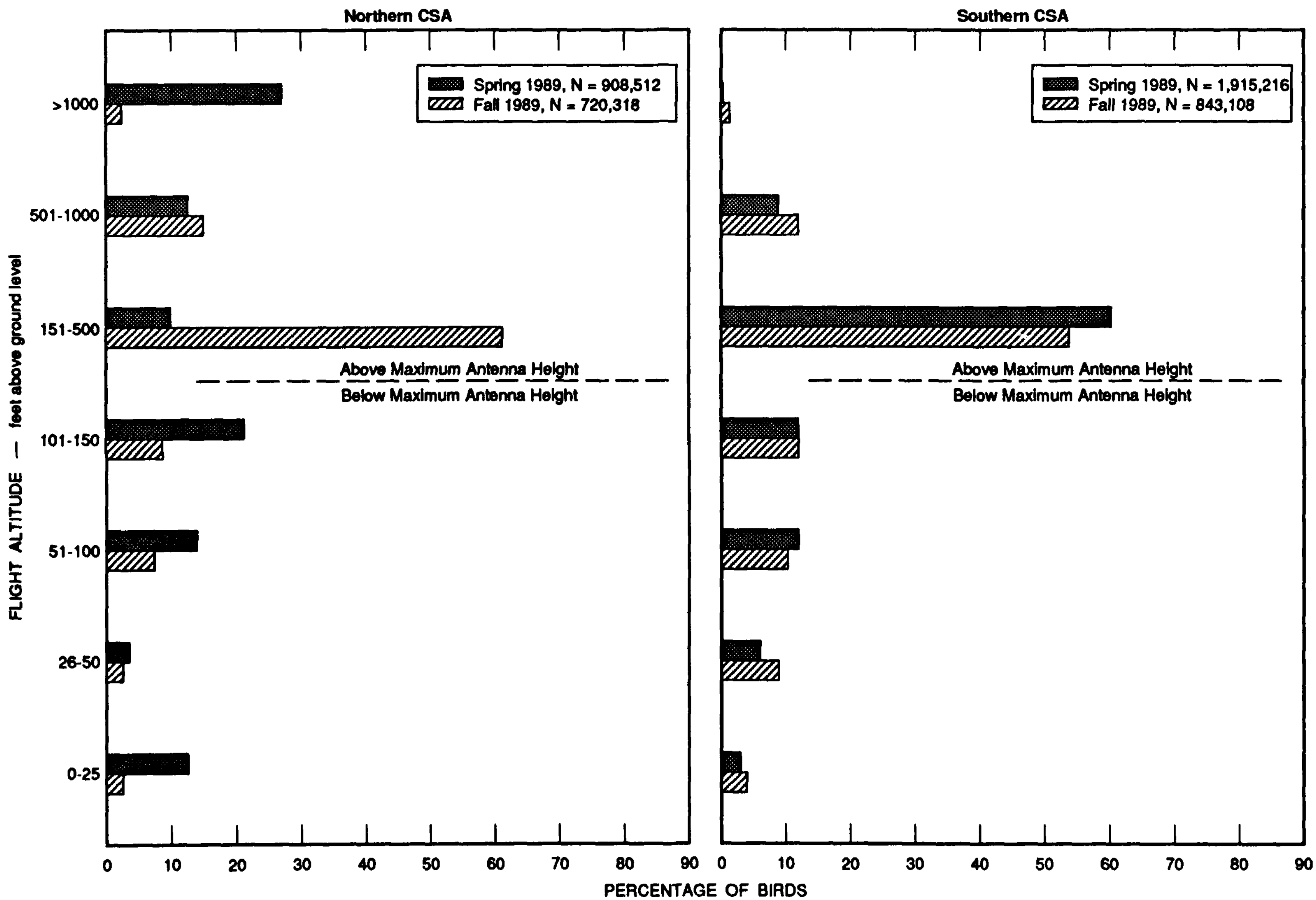
migrate during either day or night include ducks, geese, swans, loons, grebes, shorebirds, herons, gulls, and terns. Within the latter group, ducks and shorebirds migrate predominantly at night.

Flight Altitudes—Flight altitudes varied markedly among species groups and among individual flocks within species groups, but in the transmit study area substantial fractions of most species flew below 135 ft (see Figures 3.6.1 and 3.6.2). Precipitation, wind speed, and the height of the cloud ceiling affected flight altitudes for many species, although all species were not equally sensitive to these variables, nor did all react in the same manner. The observations, however, tended to agree with prior observations that daytime migrants generally fly lower when visibility is poor, cloud ceilings are low, rain or snow is falling, or strong headwinds exist. Table 3.6.2 shows the percentage of birds in each species groups observed flying below 150 ft above ground level (agl). Night-flying birds most commonly flew at 300-500 ft agl during the spring, but altitudes averaged more than 900 ft agl at both CSAs during the period of heaviest waterfowl migration. Altitudes were much lower during the fall when more than half of the detected birds were between 100 and 300 ft agl.

Northern CSA—Large percentages of the birds in most species groups flew below 150 ft agl in the northern transmit CSA during the day (See Table 3.6.2). The percentages appeared to vary from season to season, although variations in data recording methods contribute to the variation. The percentage of geese flying at low altitudes varied from 0.6% below 100 ft agl in the spring of 1988 to 50% below 150 ft agl in the spring of 1989. The percentage of blackbirds flying at low altitudes varied from 32% below 100 ft agl to 97% below 150 ft agl.

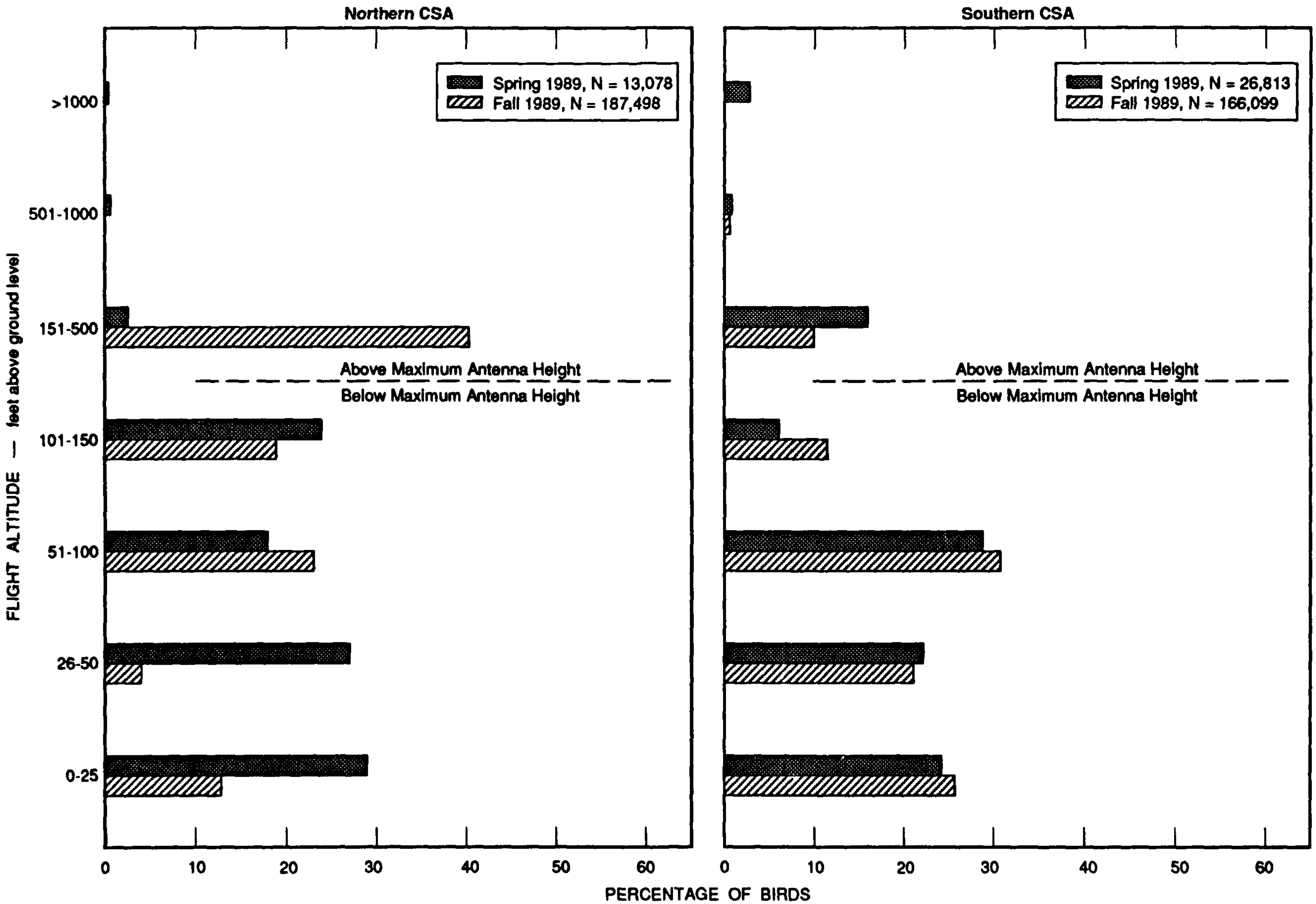
Flights altitudes during the night were mostly at altitudes above 300 ft in the spring and below 300 ft in the fall.

Southern CSA—Large percentages of the birds in most species groups flew below 150 ft agl in the southern transmit CSA during the day. The percentages flying low, however, varied from season to season. The percentage of geese, the most abundant waterfowl group, that flew below 150 ft agl ranged from 30% in the spring of 1989 to 34% in the fall of 1989. Percentages



SOURCE: U.S. Air Force

FIGURE 3.6.1 TRANSMIT STUDY AREA DIURNAL FLIGHT ALTITUDES — ALL WATERFOWL



SOURCE: U.S. Air Force

FIGURE 3.6.2 TRANSMIT STUDY AREA DIURNAL FLIGHT ALTITUDES — ALL PASSERINES

Table 3.6.2
PERCENTAGES OF BIRDS OBSERVED FLYING BELOW 150 FT AGL AT THE TRANSMIT STUDY AREA DURING SPRING AND FALL 1989 MIGRATIONS.

	Northern CSA	Southern CSA
Waterfowl	38	32
Raptors	69	75
Shorebirds	91	85
Sandhill Cranes	26	59
Waterbirds	66	69
Gamebirds	100	100
Passerines	62	89

Source: Metcalf & Eddy/Holmes & Narver, 1990H.

for blackbirds, the most common passerine group, were also nearly constant at 88% in the fall and 90% in the spring of 1989.

Flight altitudes during the night were mostly above 300 ft agl in the spring. Low flights were common in the spring and uncommon in the fall.

Flight Directions—Waterfowl showed more consistency in daytime direction of flight in the spring than in the fall and did not differ much between observation stations in the transmit study area. Ducks generally flew north or northwest in the spring, but were highly variable in the fall, indicating a high proportion of local movements. Geese also showed more directionality in the spring, when they primarily flew north. However, geese frequently flew east and west during

the fall. Swans flew mainly in the expected migratory directions in both seasons: north, northwest, and west in the spring; and east, southeast, and south in the fall.

Shorebirds and water birds showed considerable variability in daytime flight directions in both seasons, suggesting a high frequency of local movements. North was the most common direction in the spring, and south the most common direction in the fall.

Raptors generally flew either north or south, depending upon the season, but a fair amount of local movement, attributable to northern harriers, also occurred. Passerines moved mainly north, northwest, or west in the spring and south in the fall.

Nocturnal flights, as observed by long-range radar, were generally north and northwest in the spring, and south or southeast in the fall. Flight directions were more variable in the spring, suggesting a greater proportion of local movements.

Flock Sizes—Flock sizes typically varied 10-100-fold within species groups and even more between species groups. The species groups with the largest average flock size, when flying by day, were geese (900), ducks (180), and blackbirds (200). All others tended to travel singly, in pairs, or in small flocks averaging 5-20 birds when flying by day. Flock sizes by night could not be reliably estimated.

Bird Concentration Areas—During aerial surveys of birds on the ground, large numbers of waterfowl were seen in wetland complexes and the extensively flooded areas near the southern CSA. Concentrations of about 28,000 birds were observed at or near South Slough, Renzienhausen Slough, and the Southern CSA in the spring of 1989. Concentrations of 12,000-36,000 waterfowl occurred at or near Renzienhausen Slough, South Slough, Mary's Slough, and the southern CSA in the fall.

Breeding Populations—Two greater prairie-chicken leks and one sharp-tailed grouse lek were found within the CRS transmit site study area, with generally 6-12 birds using each lek. Low to moderate numbers of raptors, ducks, and shorebirds are presumed to breed within the

study area, although no active nests were seen during aerial surveys. Ground censuses for passerines were not feasible because ground access was not permitted for most of the study area; prior studies in the region found average total breeding densities of 0.6 breeding pairs of passerines per acre of native grassland habitat.

Radio Tower Collision Assessments—During 60 surveys of the ground around a guyed and an unguyed tower near the CRS transmit study area, 38 dead birds were found. Approximately 60% were passerines, and most of the others were water birds, shorebirds, and ducks. One was a game bird, and one was unidentifiable. Over 90% of the kills were at a guyed, 400-ft tall TV tower at the edge of Britton, South Dakota. The other 10% occurred at the 308-ft unguyed tower 5 mi west of Britton.

3.6.1.5 Threatened and Endangered Species

The CRS transmit study area is within the geographic ranges of seven species that are federally listed as threatened or endangered and four species *of state concern* (see Table 3.6.3). Four these species, the bald eagle, peregrine falcon, osprey, and buff-breasted sandpiper, were observed migrating through the study area. The other eight are species whose presence or absence cannot be definitely determined at this time. However, the absence of suitable habitats and the lack of recent reports for all of those species except the orchid indicate they are probably absent. Suitable habitat probably exists for the eighth species, the Western prairie fringed orchid, but lack of site access prevented determination of its presence or absence.

The two federally listed species observed in the study area are the bald eagle and the peregrine falcon; both are endangered. Bald eagles were sighted 82 times during the 1987, 1988, and 1989 bird surveys. Forty two sightings were made in the southern CSA, 20 in the northern CSA, and 20 were made during road surveys or general observations. Eagles were flying below 150 ft in 79% of the observations within the two CSAs. Peregrine falcons were sighted twice: once at the northern CSA and once at the southern CSA. Both observations were made in the fall of 1989. Both birds were flying below 150 ft.

Table 3.6.3
THREATENED AND ENDANGERED SPECIES THAT MAY INHABIT THE CRS TRANSMIT STUDY AREA

Common Name	Scientific Name	Status
Federally listed species		
Peregrine falcon	*Falco peregrinus*	Endangered
Bald eagle	*Haliaeetus leucocephalus*	Endangered
Whooping crane	*Grus americana*	Endangered
Piping plover	*Charidrius melodus*	Threatened
Eskimo curlew	*Numenius borealis*	Endangered
Burying beetle	*Nicrophorus americanus*	Endangered
Western prairie fringed orchid	*Platanthera praeclara*	Threatened
Species of State Concern		
Osprey	*Pandion haliaeetus*	Threatened
Buff-brested sandpiper	*Tryngites subruficollis*	Threatened
Northern redbelly snake	*Storeria occipitomaculata*	Threatened
Northern lined snake	*Tropidoclonion lineatum*	Threatened

Source: Metcalf & Eddy/Holmes & Narver, 1990I.

The whooping crane was not seen. The probability of its occurrence is very remote because the population size is exceedingly small, and its main migration corridor is west of the study area.

The Western prairie fringed orchid historically occurred in wet meadows in the Big Sioux River Valley, and the wetter portions of the study area may be suitable habitat. However, the orchid is not now known to occur in South Dakota.

The absence of the piping plover, Eskimo curlew, and burying beetle appears to be attributable to small populations and to the lack of suitable habitat. The piping plover uses sparsely vegetated sloughs and saline wetlands in prairie ecosystems; these are absent in the study area. The Eskimo

curlew was formerly an abundant spring migrant, but has not been sighted in South Dakota for more than 100 years. Swift fox habitat is present, but probably not in sufficiently large contiguous tracts to support a population. The burying beetle has been found only in two colonies in the past 10 years. Neither colony is near the study area.

The species of state concern seen in the study area are the osprey and the buff-breasted sandpiper; both are threatened. Two ospreys were seen at the southern transmit CSA, and both were above 150 ft agl. One buff-breasted sandpiper was seen in the study area, but outside both CSAs.

The species of state concern not seen in the transmit study area were the northern redbelly snake and the northern lined snake. The northern redbelly snake inhabits open woodlands and sphagnum bogs, habitats not present in the CRS transmit study area. The northern lined snake is unlikely to be present because its historical range in South Dakota included only the southeastern corner of the state.

3.6.2 Receive Study Area

3.6.2.1 Vegetation

Historically, the CRS receive study area was in a vegetation transition zone between the oak savanna that marked the western edge of the eastern deciduous forests and the tall-grass prairies. Less than 1% of Minnesota's tall-grass prairies remain intact. Because of its value as agricultural land, most of the land in the study area is now in crops. Cultivated lands make up nearly 79% of the study area, grasslands 11%, deciduous forests 6%, and wetlands 4%. Crops typically include wheat, oats, barley, alfalfa, sunflowers, soybeans, sugar beets, potatoes, and small amounts of buckwheat and flax.

The prairie remnants in the study area may consist of mesic blacksoil prairies or wet blacksoil prairies. The Minnesota Department of Natural Resources considers both to be threatened. If

these remnants are present, they may contain one or more of the four plant species of special concern that are found near the study area.

Natural woodlands in the CRS receive study area are found primarily in the eastern portion and are primarily aspen parklands, which are mosaics of aspen groves, sedge meadows, shrub thickets, and open prairies. Shrubs include pussy willow, hazelnut, choke cherry, and red osier. Common trees are aspen, poplar, and bur oak. Planted woodlands consist of shelterbelts and woodlots, primarily of evergreen species.

Designated prime farmland (including lands that could be prime farmland if drained) make up 63% of the study area, and designated farmlands of statewide importance cover another 3%. Designated prime farmlands comprise 69% of the western CSA and 70% of the eastern CSA.

Eastern CSA—The eastern receive CSA is characterized by beach strands from Glacial Lake Agassiz and associated wetlands. They are most abundant in the central portion of the CSA. The current vegetation consists of large tracts of cropland with interspersed grasslands and relatively large forested tracts and wetlands. The latter are primarily in the central portion of the CSA where the beach strands occur. Prime farmland and farmlands that could be prime if drained cover 70% of the CSA, and 3% is land of statewide importance.

Western CSA—The western receive CSA is flat and gently sloping; 95% of the western CSA is in cultivated fields (75%) or grassland (20%). Native shrubs and woodlands cover 3% of the CSA, and planted trees cover 1%. Wetlands are small and scattered throughout the CSA. Prime farmlands and farmlands that could be prime if drained account for 69% of the area, and 1% is land of statewide importance.

3.6.2.2 Wetlands

Wetlands occupy approximately 6,120 acres (6%) of the CRS receive study area. The water quality characteristics of wetlands of the region are described in Section 3.6.1.2. Of these wetlands, about 3,660 acres or 60% are emergent wetlands (59%) and ponds (1%). Combinations

of emergent vegetation shrubs, and trees cover 1,763 acres (29% of all wetlands). Broadleave trees and shrubs cover 9% of all wetlands, and streambeds account for about 2%.

Habitat for aquatic species consists of a network of drainage ditches and Goose Lake, bu only the latter is a dependable environment. Most of the drainage ditches are not considere fishery resources, especially in dry years, but in wet years may contain brook sticklebacks an fathead minnows. Goose Lake is a designated wildlife management area and a state-protecte water resource. The Snake River, a tributary of the Red River of the North, is 2 mi north of th study area.

Eastern CSA—One-hundred and ninety-two distinct wetlands cover 1,046 acres (6%) o the eastern receive CSA. Up to 70% of these wetlands lack surface water through the growin season, but approximately 30% briefly retain water early in the growing season. Emergen wetlands account for 39% of all wetlands, emergent and shrub combinations 23%, and shrub dominated wetlands 18%. Combinations of emergent vegetation and forest cover 11%, an forested wetlands account for 7% of all wetlands. All wetlands occur in small parcels, averagin 1-8 acres.

Two large drainage ditches are located in the eastern receive site CSA, both flowing fror north to south. One ultimately drains westward into the Snake River and the Red River of th North, and the other continues south and drains into the Black River. The ditches may suppo species such as northern pike and minnows.

The emergent vegetation in the wetlands is predominantly cattails, rushes, and sedge Willows, dogwoods, hawthorn, quaking aspen, cottonwood, and box elder are common in th shrub-and forest-dominated wetlands.

Western CSA—Wetlands cover 465 acres (4%) of the western receive CSA. Emerge vegetation covers 345 acres or 74% of all wetlands, forests 82 acres (18%), ponds 9 acres (2% and shrublands 28 acres (6%). There are 548 distinct wetlands averaging less than 1 acre in are The only habitat for aquatic species is a drainage ditch that may support sticklebacks, minnow

and invertebrates in some years. An estimated 30% of the wetlands are seasonally flooded, and the remaining 70% are temporarily flooded, probably only during the first few weeks of the growing season. The vegetation in these wetlands is similar to that of the eastern CSA.

3.6.2.3 Mammals

The mammals discussed in this section are those species selected in consultation with USFWS and the Minnesota Department of Natural Resources. Other, smaller mammals are not included because their large populations and ubiquitous distributions make significant impacts on their populations improbable and because their low economic importance makes economic impacts from any changes in these populations equally improbable. Federal and state-listed threatened or endangered mammalian species are discussed in Section 3.6.2.5.

Eastern CSA—Moose and white-tailed deer are both relatively abundant near, but not necessarily in, the eastern receive CSA. Red fox, striped skunk, raccoon, and muskrat are known or expected to be relatively abundant in the CSA, and bobcats may be present in the easternmost portions. Coyote, badger, and weasel are probably present in lower numbers.

Moose are present year-round in the eastern CSA, and moose densities are at least one moose per 1-2.5 mi^2. Their preferred winter habitat in the receive study area is woodland, and the important summer habitats are small shallow lakes and marshes. They forage on balsam fir, aspen, paper birch, red osier, willow, and various other shrubs and small trees throughout the year, as well as milfoil, cattail, and other aquatic plants during the spring and the summer. Aerial surveys during the winters of 1988 and 1989 found moose ,rimarily in areas immediately south or east of the CSA that have more suitable habitat than the CSA. Relatively few were found within the CSA itself. In the easternmost part of the CSA, however, there were 4 sightings of 1-6 moose during winter aerial surveys in 1988 and 5 sightings in 1989. In the western portion of the eastern CSA, 2 sightings occurred in 1988 and 4 in 1989.

Deer in Minnesota typically winter in large wooded areas, swamps, and marshes with thick vegetation, and return to smaller upland woods and fields in the spring. The deer populations are limited by the availability of winter habitat, and white cedar and balsam fir forests are particularly important. These preferred habitats are absent from the CSA, but the woodlots and shelterbelts in the CSA may provide some winter habitat.

Western CSA—Few moose and virtually no deer were seen in the CSA during the 1988 and 1989 winter surveys. Those that were seen were concentrated in the wooded areas in the southwestern portion of the CSA. However, 3 groups of 2-6 moose and 2 individual moose were seen in the 1988 surveys, and 3 individual moose were seen in 1989. Both winter and summer habitat for moose are uncommon in the western CSA, limiting the number of moose.

Striped skunk and red fox are abundant in the study area, and moderate populations of muskrat, mink, and raccoon are also present. Coyote, bobcat, badger, and weasels are occasional inhabitants.

3.6.2.4 Birds

Bird Populations—Total numbers of birds are considerably lower near the CRS receive study area than at the transmit study area, but are nonetheless substantial. The Agassiz National Wildlife Refuge, about 12 mi northeast of the receive site study area, receives peaks of 800-5,000 geese in the spring, and 8,000-28,000 geese in the fall. Spring peak duck populations range from 15,000-70,000, and fall populations range from 30,000-130,000. Gulls and terns also use the area heavily, with up to 4 million annual use days. Pembina Wildlife Management Area, located within the study area, also receives moderate to heavy use by waterfowl, although quantitative historical records are not available.

Similar numbers of birds were observed in the eastern and western portions of the receive study area during 1989. About 230,000 birds were seen at the western CSA, and about 270,000 in the eastern CSA. The western portion of the eastern CSA, where the Rx-E preliminary site layout

occurs, probably had similar numbers of birds as well. As at the transmit study area, geese, ducks, and passerines were the most numerous birds, but a total of 194 species were seen (see Table 3.6.4).

Table 3.6.4
NUMBER OF BIRDS OBSERVED DURING DAYLIGHT HOURS AT THE CRS RECEIVE CSAs DURING SPRING AND FALL 1989 MIGRATIONS[a]

	Western CSA		Eastern CSA Central Station[b]	Eastern CSA East Station[b]	
Waterfowl	122,000	(25,800)	(22,880)	80,7800	(32,500)
Geese	106,000	(24,300)	(21,100)	69,400	(30,200)
Ducks	11,300	(484)	(1,030)	9,880	(996)
Raptors	1,080	(701)	(747)	969	(620)
Shorebirds	2,340	(1,780)	(1,680)	1,480	(857)
Sandhill Cranes	3,930	(1,550)	(2,220)	5,170	(1,320)
Waterbirds	8,080	(2,190)	(2,270)	11,400	(3,540)
Gamebirds	181	(171)	(305)	302	(243)
Passerines	96,100	(33,100)	(34,070)	167,000	(41,500)
Blackbirds	19,800	(3,440)	(12,000)	11,300	(3,680)

a Fall numbers in parentheses.

b The Eastern CSA contains the central station in the western portion of the CSA and the eastern station in the eastern portion of the CSA. Observations were not conducted at the central station during spring 1989.

SOURCE: Metcalf & Eddy/Holmes & Narver, 1990H

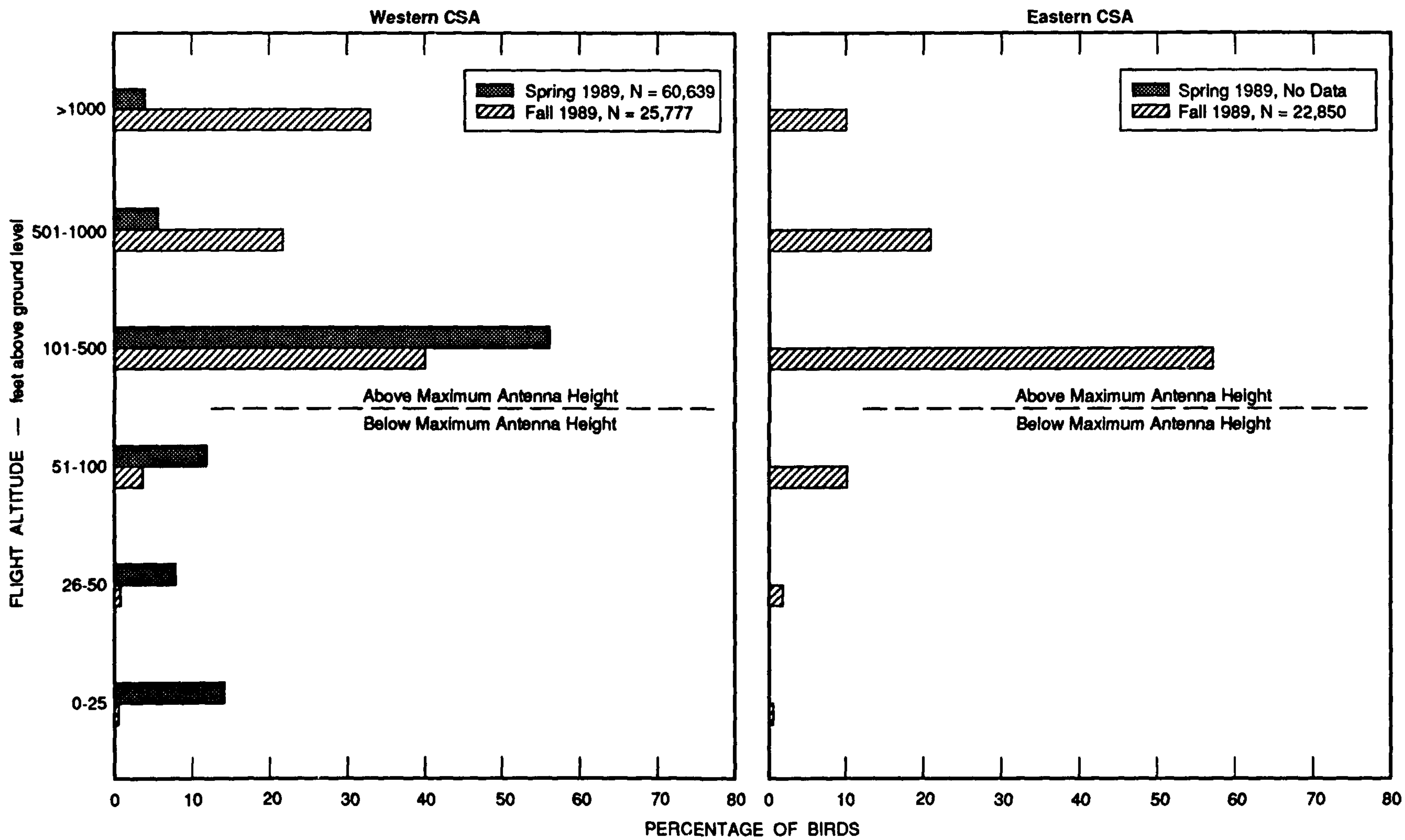
Annual Migration Periods—The general pattern of bird migration at the CRS receive study area is similar to that at the transmit study area, as discussed in Section 3.6.1.4.

Migration Rates—Only three species groups out of seven had average daytime migration rates less than one bird per hour at one or more observation stations during at least one season in 1989. Waterfowl had average migration rates in the CSAs in 1989 of 29-100 birds per hour, passerines of 43-129 birds per hour, waterbirds of 2.8-8.0 birds per hour, sandhill cranes of 1.7-3.9 birds per hour, shorebirds of 0.6-2.3 birds per hour, raptors of 0.4-1.0 birds per hour, and game birds of 0.01-0.4 birds per hour. Peak daytime migration rates in 1989 were 350-1,500 birds per hour for waterfowl, 130-2,000 birds per hour for passerines, 50-150 birds per hour for waterbirds, 39-42 birds per hour for sandhill cranes, 4.6-111 birds per hour for shorebirds, 0.9-6.6 birds per hour for raptors, and 0.3-4.3 birds per hour for game birds.

Peak night and evening migration rates were also variable, but roughly correspond to daytime patterns. However, the spring observation period was incomplete, and only numbers of targets (flocks), not numbers of birds could be counted, as explained in Section 3.6.1.4. The data indicate that large numbers of birds move through the receive study area at night. Peak migrations rates observed with the long-range radar ranged from 51-95 targets per hour, but average nightly rates were generally below 25 targets per hour in both CSAs. Mean migration rates obtained with the long-range radar varied from 13-19 targets per hour. Peak rates observed with the short-range radar varied from 347-1,540 targets per hour. Mean rates ranged from 121-301 targets per hour.

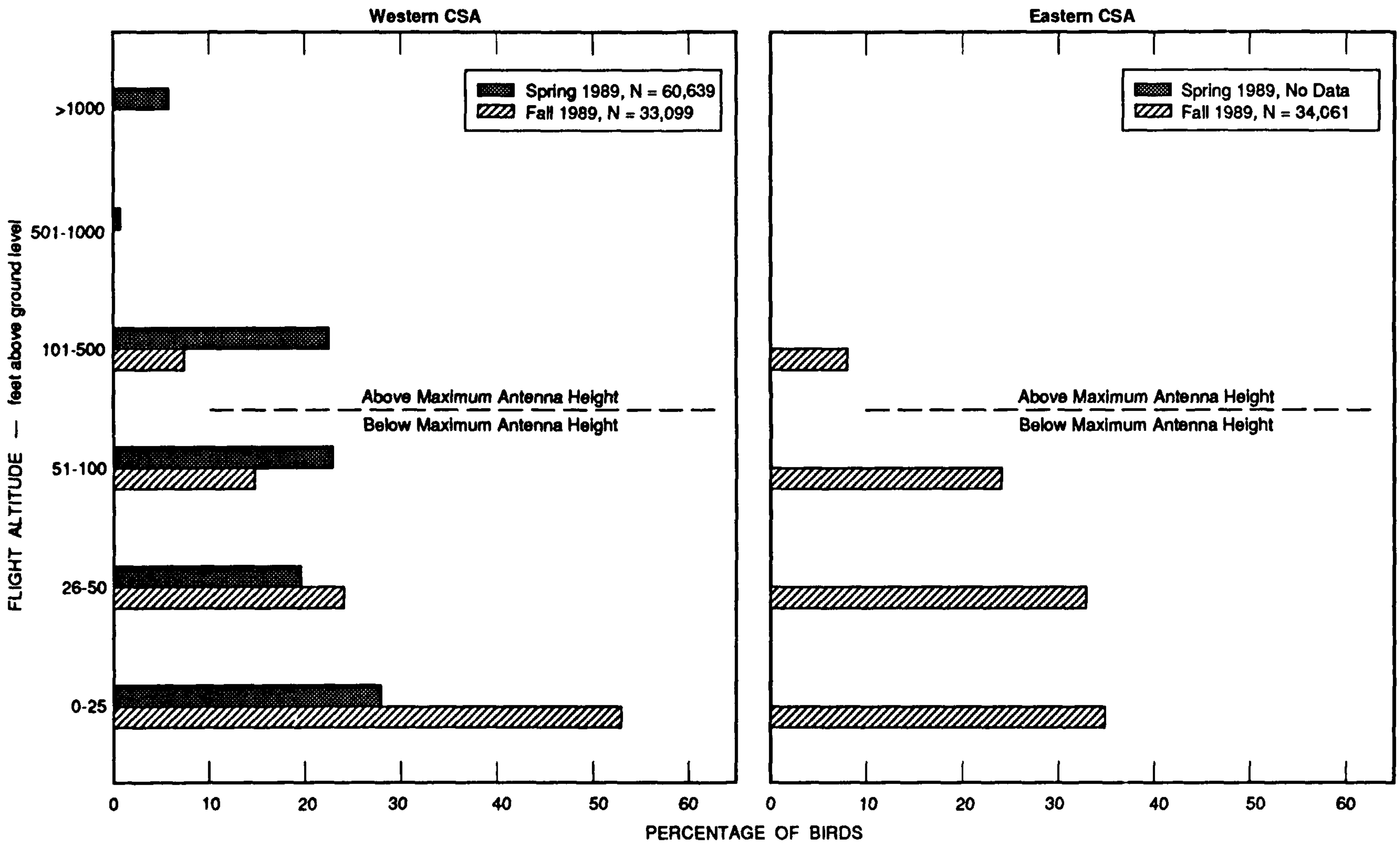
Daily Flight Times—The daily patterns of flight at the receive study area are similar to those described for the transmit study area in Section 3.6.1.4.

Flight Altitudes—At each location in the receive study area, substantial fractions of most species groups flew below 75 ft agl (see Figures 3.6.3 and 3.6.4), but flight altitudes varied markedly among species groups and among individual flocks within species groups. Waterfowl, water birds, and sandhill cranes generally flew higher in the fall than in the spring. Raptors, game birds, shorebirds, and passerines flew at roughly the same altitudes in both seasons. Variations in



SOURCE: U. S. Air Force
NOTE: The eastern CSA flight altitudes are based on data obtained at the central observation station of the receive study area (see also Metcalf & Eddy / Holmes & Narver, 1990H).

FIGURE 3.6.3 RECEIVE STUDY AREA DIURNAL FLIGHT ALTITUDES — ALL WATERFOWL



SOURCE: U. S. Air Force
NOTE: The eastern CSA flight altitudes are based on data obtained at the central observation station of the receive study area (see also Metcalf & Eddy / Holmes & Narver, 1990H).

FIGURE 3.6.4 RECEIVE STUDY AREA DIURNAL FLIGHT ALTITUDES — ALL PASSERINES

flight altitudes associated with variations in precipitation, wind speed, and the height of the cloud ceiling are discussed in Section 3.6.1.4. The species groups with the highest percentages of low-flying individuals during the day were gamebirds, shorebirds, and passerines (80-100%). Percentages for raptors (70%) were intermediate, and percentages for sandhill cranes, waterfowl, and waterbirds were low (7-28%), as shown in Table 3.6.5.

Large percentages of the birds in most species groups flew below 100 ft agl during the day in the eastern receive CSA (see Table 3.6.5). The percentages flying below 100 ft agl, however, appeared to vary from season to season. Between 9-23% of geese, the most abundant waterfowl, flew below 100 ft agl. The percentage of blackbirds, the most common passerine, flying below 100 ft agl ranged between 92-95%.

Table 3.6.5
PERCENTAGES OF BIRDS OBSERVED FLYING BELOW 100 FT AGL AT THE RECEIVE STUDY AREA

	Western CSA	Eastern CSA[a]
Waterfowl	28	11(26)
Raptors	69	70(60)
Shorebirds	83	90(83)
Sandhill Cranes	22	10(37)
Waterbirds	29	7(20)
Gamebirds	100	100(100)
Passerines	80	92(94)

a Central Station percentages (East Station percentages)

SOURCE: Metcalf & Eddy/Holmes & Narver, 1990H

Night-flying birds at the eastern CSA most commonly flew at 300-500 ft agl during the spring, but altitudes were much lower during the fall when more than half of the birds detected with radar flew between 100- 300 ft agl. The numbers of birds flying below 100 ft appear to be low in both spring and fall. Migration rates for birds flying below 100 ft were 0.03 birds per hour in the spring and 0.01 birds per hour in the fall at the station nearest the eastern CSA. At the observation stations in the eastern portion of the CSA, the rates were 1.2 birds per hour in the spring and 0.07 birds per hour in the fall.

Large percentages of the birds in most species groups flew below 100 agl during the day in the western receive CSA. The percentages flying low, however, appear to vary from season to season. About 4.4% of geese, the most abundant waterfowl, flew below 100 ft agl in the fall of 1989. About 77% of blackbirds, the most common passerine, flew below 100 ft agl.

Night-flying birds at the western CSA most commonly flew at 300-500 ft agl during the spring. Altitudes were much lower during the fall when more than half the targets detected by radar were between 100 300 ft agl. The migration rates for birds flying below 100 ft, as determined with the night vision scope, were 7.9 birds per hour in the spring and 0.06 birds per hour in the fall.

Flight Directions—Waterfowl showed more consistency in direction of flight in the fall than in the spring. Ducks generally flew south, southeast, or southwest in the fall, but were highly variable in the spring, indicating a high proportion of local movements. Geese showed more directionality. Geese generally flew north, northeast, or northwest in the spring, and south, southeast, and southwest in the fall. Swans flew mainly in the expected migratory directions in both seasons: north, northwest, and west in the spring, and east, southeast, and south in the fall.

Shorebirds showed considerable variability in flight directions in both seasons. This variability suggests a high frequency of local movement.

Sandhill cranes generally flew north or northeast in the spring and south, southeast, and southwest in the fall. At Goose Lake, however, a high proportion of local movement occurred as cranes staged and roosted in the area.

Water birds generally flew north or northwest in the spring and south or southeast in the fall, except at the observation station at Goose Lake, when fall movements were generally to the east, and in the eastern CSA, where movements were highly variable.

Raptors generally flew either north or south, depending upon the season. A fair amount of local movement, attributable to northern harriers, also occurred.

Passerines moved mainly north in the spring, except in the western CSA and at Goose Lake. Flight directions were variable at all observation stations in the fall, but flights to the south were most common. Blackbirds generally showed more directionality than other passerine groups.

Nocturnal flights, as observed with long-range radar, were generally north and northwest in the spring, and south or southeast in the fall. Flight directions were more variable in the spring, suggesting more local movement.

Flock Sizes—Average flock sizes were 36-112 geese, 3-73 ducks, 10-321 blackbirds, 14-98 passerines (other than blackbirds), 3-38 sandhill cranes, and 9-41 swans, depending on season and location. Except for raptors, which generally traveled alone or in very small flocks averaging 1-2 birds, all other species groups tended to travel in small-to moderate-sized flocks averaging less than 84 birds. Flock sizes by night could not be reliably estimated.

Bird Concentration Areas—During aerial surveys of bird concentrations on the ground at the CRS receive study area, seasonal totals of 1,000 or more waterfowl were seen at or near the Thief River Falls sewage lagoons (about 10 mi east of Rx-E), Goose Lake, and the western CSA during the spring. Comparable concentrations of birds, however, were seen only near the sewage lagoons in the fall.

Road surveys gave somewhat similar results, although the sewage lagoons were not included. Waterfowl were most abundant near Goose Lake and the western CSA in the spring, and relatively rare elsewhere. In the fall, the distribution of waterfowl was fairly equal among the western CSA, Goose Lake, and the eastern CSA, although the western CSA had the lowest numbers among these three areas.

Breeding Populations—Within the receive study area, one greater prairie-chicken lek and four sharp-tailed grouse leks were found, with 4-10 birds using each lek. Low to moderate numbers of raptors, waterfowl, and shorebirds are presumed to breed within the study area, although no active nests were seen during aerial surveys. Ground-based censuses for passerines were not conducted because rights of entry were not available for most of the study area.

Radio Tower Collision Assessments—More than 90% of the birds killed were found at towers 400 ft tall or taller. Only 15 birds were found at the two Minnesota towers that are less than 325 ft tall, but 221 birds were *found* beside two towers that were over 385 ft tall.

3.6.2.5 Threatened and Endangered Species

The CRS receive study area is within the geographic ranges of 14 federally and state-listed threatened and endangered species (Table 3.6.6). Four of these species, the bald eagle, peregrine falcon, sprague's pipit, and loggerhead shrike are birds which were observed migrating through the study area. The presence or absence of several of the others cannot be determined at this time; however, their occurrence is unlikely because their habitat needs are incompatible with the intensive farming characteristic of the study area.

The three federally listed species historically seen in the study area are the peregrine falcon, piping plover, and bald eagle. Bald eagles were sighted 32 times, including 31 sightings in 1989. Peregrine falcons were seen nine times, all in 1989. Three sightings were at the western receive CSA and four at the eastern receive CSA. In five of these seven sightings, the birds were resting

Table 3.6.6
THREATENED AND ENDANGERED SPECIES THAT MAY INHABIT THE CRS RECEIVE STUDY AREA

Common Name	Scientific Name	Status
Federally listed species		
Gray wolf	*Canis lupus*	Threatened
Peregrine falcon	*Falco peregrinus*	Endangered
Piping plover	*Charidrius melodus*	Threatened
Bald eagle	*Haliaeetus leucocephalus*	Threatened
State-listed species		
Assiniboia skipper	*Hesperia assiniboia*	Endangered
Baird's sparrow	*Ammodramus bairdii*	Endangered
Sprague's pipit	*Anthus spraguii*	Endangered
Chestnut-collared longspur	*Calcarius ornatus*	Endangered
Burrowing owl	*Athene cunicularia*	Endangered
Loggerhead shrike	*Lanius ludovicianus*	Threatened
Hall's sedge	*Carex halli*	Threatened
Sterile sedge	*Carex sterilis*	Threatened
Hair-like beak rush	*Rhynchospora capillacea*	Threatened
Annual skeleton weed	*Lygodesma rostrata*	Threatened

Source: Metcalf & Eddy/Holmes & Narver, 1990I.

or flying below 65 ft. The bald eagle is threatened in Minnesota; the peregrine falcon is endangered. No piping plovers were seen during the bird studies of 1987, 1988, and 1989.

The federally listed species not seen is the gray wolf, which is listed as threatened in Minnesota. The nearest wolf population is about 25 mi east of the study area. Although wolves might stray into the study area, this is unlikely.

Two state-listed species, Sprague's pipit and the loggerhead shrike, were seen in the receive study area, but three other birds—Baird's sparrow, the chestnut-collared longspur, and the burrowing owl—and a butterfly may occur in the study area. Baird's sparrow and Sprague's pipit both were known to breed in dry uplands of the Red River of the North Valley, but for the past 20 years have been regularly observed only on the Fenton Prairie about 70 mi south of the study area. The chestnut-collared larkspur is not known to inhabit the study area, but suitable habitat is abundant, and it could colonize the area. In Minnesota, the loggerhead shrike is now known to breed consistently only in areas south of the study area. The burrowing owl rarely breeds in Minnesota now, and none of the breeding areas is near the study area. No burrowing owls were seen, and little suitable habitat is available. The butterfly, the assiniboia skipper, has been observed 20 mi west of the study area and is most abundant 70 mi to the south, but the beach ridge at the eastern receive site contains suitable habitat.

All of the four state-listed plant species that may also occur in the receive study area are threatened. Of these species, three occur in groundwater seepage areas and may inhabit the uncultivated area just west of the beach ridges at the eastern receive CSA. The other species, annual skeleton weed, is an inhabitant of unstable dunes and is less likely to be encountered.

3.6.3 Power Supply

3.6.3.1 Transmit Site

Vegetation—The vegetation of the transmit-site powerline study area is generally similar to that described above for the Transmit Study area. All of the links except for Link 7 primarily cross cultivated fields. Chief crops are spring wheat, flax, corn, oats, barley, alfalfa, sunflowers, and sorghum. Many areas of temporarily flooded palustrine emergent wetlands are cultivated. Link 7 is mostly native rangeland and prairie. A portion of Link 7 is within the Hecla Sandhills, a unique landform that supports big bluestem, blue gama, and associated grasses and forbs. Trees

occur primarily in shelterbelts and along drainage channels and provide important but scarce wildlife habitat.

Up to 62% of the powerline study area is designated prime farmland or farmland of statewide importance. Links 5,7, and 8 have the lowest percentage of prime or statewide farmland.

Wetlands—The most common type of wetland habitat in the area is palustrine emergent. Over 90% of the wetlands in the links are temporarily, seasonally, or semi-permanently flooded palustrine emergent wetlands. Table 3.2.1 shows the amount of wetlands found in each link. In general, the percentage of wetland area increases from south to north across the study area. Additionally, the corridors of the southern study area are generally flooded for shorter periods than those of the northern study area. The wildlife value of wetlands is positively correlated with the duration of standing water; thus, the temporary wetlands of the southern study area have lower wildlife value than the more permanent wetlands of the northern study area. Many of the temporarily flooded wetlands are farmed when the water dissipates.

Mammals—The principal mammals of the transmit study area described in section 3.6.1.3 also occur in the powerline study area. Those species include white-tailed deer, red fox, coyote, muskrat, striped skunk, badger, mink, jackrabbit, longtail weasel, and raccoon. Cultivated land provides habitat for deer and pronghorn antelope. Wetlands provide habitat for mink, muskrat, skunk, red fox, weasel, and raccoon. Forested areas are important habitat for deer and the smaller mammals. Because of the abundance of wetlands and native vegetation, Link 7 contains the most valuable wetland habitat.

Birds—The avian resources of the powerline study area are generally as described for the transmit study area in section 3.6.1.4. The area is within the Central Flyway and supports hundreds of thousands of migrating birds each spring and fall, providing important breeding habitat for passerines. The most abundant migrants are passerines and waterfowl , particularly snow geese. Waterfowl use the wetlands and cultivated land for resting and feeding during migration. Important wildlife areas of the region include Sand Lake National Wildlife Refuge,

Dakota Lake National Wildlife Refuge, Renzienhausen Slough Game Production Area, and Hyatt's Slough Waterfowl Management Area.

Threatened and Endangered Species—Federally listed threatened and endangered species which may occur in the powerline study area include bald eagles, peregrine falcon, Western prairie fringed orchid, whooping crane, piping plover, eskimo curlew, and burying beetle. During avian surveys conducted in 1987-1989, 82 bald eagles were sighted; most were near wetlands and waterways. Two peregrine falcons were also observed. The Western prairie fringed orchid may occur in the Hecla sandhills of Links 7 and 8, but is unlikely to occur in the other links. No whooping cranes, piping plover, or eskimo curlews were observed during the avian surveys, and they are considered unlikely to occur in the powerline corridors. The burying beetle is not known to inhabit the powerline study area.

3.6.3.2 Receive Site

Vegetation—The vegetation of the receive-site powerline study area is generally similar to that described in section 3.6.2.1 for the receive study area. About 80% of the land in the powerline study area is estimated to be cultivated. Major crops include spring wheat, sunflowers, oats, barley, sorghum, alfalfa, soybeans and sugar beets. Up to 69% of the area may quality as prime farmland, depending on drainage conditions. Trees and shrubs are relatively rare. Trees occur in shelterbelts, drainage swales, and forested wetlands. Shrubs occur as understory in forests and in wetlands. Small areas of isolated mesic and wet blacksoil prairies also occur.

Wetlands—The wetlands of the receive-site powerline study area are similar to those described in Section 3.6.2.2 for the receive study area. The most common wetland type is palustrine emergent with palustrine emergent/scrub-shrub, palustrine unconsolidated bottom, and palustrine forested also commonly occurring. Some riverine wetlands occur along larger channels of the area. Table 3.2.1 shows the wetland area of each receive-site powerline corridor.

Mammals—The principal mammals of the receive study area also occur in the powerline study area. Those species include white-tailed deer, coyote, muskrat, striped skunk, badger, mink, jackrabbit, longtail weasel, raccoon, and moose. The majority of land in the powerline study area is cultivated and may provide forage for white-tailed deer. Wetlands of the corridors provide habitat for mink, muskrat, skunk, red fox, weasel, raccoon, and moose. Forested and shrubby areas are uncommon, but provide moose habitat.

Birds—As described for the receive study area in Section 3.6.2.4, the receive-site powerline study area is within the Mississippi Flyway. Large numbers of migrating birds pass through the area each spring and fall. The most common migrants are passerines and waterfowl. Aggassiz National Wildlife Refuge, about 15 mi northeast of Thief River Falls, is an important waterfowl nesting, resting, and feeding area.

Threatened and Endangered Species—Federally listed threatened and endangered species that may occur in the receive-site powerline corridors include the bald eagle, peregrine falcon, piping plover, and gray wolf. During avian surveys conducted at the receive study area, 32 bald eagles and 9 peregrine falcons were observed. No piping plovers or gray wolves were observed or are known to inhabit the powerline study area.

3.7 AESTHETICS (VISUAL RESOURCES)

3.7.1 Overview

This section and Section 4.8 of the EIS are based on a method for analyzing visual impacts developed by the U.S. Bureau of Land Management Visual Resource Management Program. (U.S. Bureau of Land Management, 1986) Scenic quality and viewer sensitivity are the key factors in describing visual resources.

Scenic quality refers to the physical features of a landscape, including both its natural features (such as landform, vegetation, water, and soils) and the human modifications that have been made

to the landscape (such as roads, buildings, and utility lines). These features make up the distinguishable line, form, color, and texture of the landscape that determine scenic quality on the basis of criteria such as distinctiveness, variety, harmony, and uniqueness. Scenic quality is perhaps best described as the overall impression an observer retains after driving through, walking through, or flying over an area.

Sensitivity represents the value of the landscape scene to the viewing public. It takes into account the number of viewers of the landscape, when and from where they view the landscape, the angle and distance of the view, the frequency of the view, and the expectations or preconceptions that viewers may have about the view.

The landscape of the CRS study areas is generally characterized as homogeneous, reflecting the flat to gently rolling topography of rural agricultural areas in the north-central United States. The angular and repetitive patterns and colors of the croplands, often bordered by single-row tree breaks, form a highly structured mosaic of color and pattern. The flat, open landscape offers expansive views from primary viewing points such as roads and residential areas. The study areas include small blocks of wooded areas and natural waterways (lakes, ponds, creeks, wetlands, and floodplain areas). These natural features add diversity of color, line, and texture to the landscape.

In addition to the cultivated fields of the CRS study areas, other human modifications to the natural landscape include power transmission lines, roads, isolated groupings of agricultural buildings (e.g., silos, barns), and farm equipment. Because of the flat, open setting and the relative sparseness of intervening vegetation, these man-made features are silhouetted along the horizon and dominate the landscape.

Four classes are used to express the landscape's scenic quality within the context of the physiographic region: Class A—Outstanding Scenic Quality; Class B—Above Average Scenic Quality; Class C—Common Scenic Quality; and Class D—Minimal Scenic Quality. Most landscapes in the study areas exhibit features common to the physiographic region (Class C). The relative lack of natural topographic features of interest and of visual diversity results in the

dominance of views by human modifications. None of the four alternative sites is within sensitive viewing distance (0-3 mi) of scenic highways, scenic overlooks, or major public use areas (e.g., parks, hiking trails). Viewer sensitivity in the study area ranges from low to moderate for landscapes that are viewed from small farm communities, rural roads, or individual residences. Table 3.7.1 summarizes the scenic quality classes and viewer sensitivity for each of the alternative transmit and receive preliminary site layouts, based on viewpoint locations near each site layout. The viewpoints selected are representative or typical of the area and allow clear views of the proposed antenna locations. Locations of historic properties which could be affected by visual impacts from CRS construction are also analyzed.

3.7.2 Transmit Study Area

3.7.2.1 Tx-N

Figure 3.7.1 shows the location of viewing points along rural roads at both the northern and southern edges of the northern transmit CSA. Viewer sensitivity is low to moderate because of limited public exposure to the sites. Scenic quality is minimal to common (Classes C and D) because the landscape lacks distinctive characteristics (see Figure 3.7.2).

3.7.2.2 Tx-S

Figure 3.7.3 shows the location of viewing points to the west and south of the southern CRS transmit CSA. Viewer sensitivity is low to moderate, with the more sensitive rating for views from eight to ten private residences located within 1 mi of the sites. Sensitivity otherwise is low with access limited to minor roads in the area. Landscape features are common to the area, lacking any distinguishable scenic features, and are generally characterized as broad, open croplands (Class C), (see Figure 3.7.4).

Table 3.7.1
VISUAL RESOURCES OF
THE ALTERNATIVE CRS SITES

Transmit Study Area	Viewpoint	Scenic Quality: Rating	Scenic Quality: Description	Viewer Sensitivity: Rating	Viewer Sensitivity: Description
Tx-N	1	Class C	Grasses, scrubbrush, fences, and cropland characterize the landscape. The land is flat to gently rolling. Scattered clusters of trees dominate the landscape and add color and form contrasting with the otherwise flat, monochromatic features	Low to mod	The view is from a paved rural road (Route 4) south onto the site. Two of the transmit antennas would be within 0.25 mi of Route 4
	2	Class C	The landscape consists of grasses, scrubbrush, flatlands, fenced croplands, and scattered trees common to the area. Rows of trees line the horizon. Wetlands and ponds dot the landscape, adding color and texture to the landscape scene	Low to mod	Viewer sensitivity is low from a dirt road that looks north toward the site. Two private residences are located within 0.5 mi of the southernmost antenna sites where sensitivity could be moderate
	Columbia Stage Trail	Class C	The landscape consists of open grassland and cropland common to the area	High	Viewer sensitivity high due to presence of historic trail
Tx-S					
	1	Class C	The land is flat. Grasses edge the road. Fields of cropland extend into the distance where there are clusters of trees	Low to mod	The view from a rural road is unobstructed and expansive and looks eastward toward the site. A cluster of homes and a school are located at the northwest corner of the study area within 0.5 mi of the road
	2	Class C	Grasslands and croplands lie on flat land. The open land extends to distant trees	Low to mod	The view is from a paved rural road. The vistas are panoramic looking northwest into the site. Transmit sectors would be within 0.5 mi of the road
	Swensen and Johnson Homesteads	Class C	The landscape characteristics are common to the area, mainly cropland	High	Viewer sensitivity high due to historic setting

Table 3.7.1 (Concluded)

Receive Study Area	Viewpoint	Scienic Quality Rating	Scienic Quality Description	Viewer Sensitivity Rating	Viewer Sensitivity Description
Rx-E	1	Class C	A dirt road edged by a row of trees dominates the landscape. Agricultural flatland stretches into the far distance with features common to the region	Low	The view is from a rural gravel road and is toward the east
	2	Class C	Grasslands are in the foreground. Croplands are beyond, and stretches of forested land are to the east	Mod	The view is from a paved rural road and looks north onto the site
	3	Class C	A grassy ditch bisects flatlands extending into the distance. Buildings in the flatlands attract the eye as they add form to the horizontal line of the horizon	Mod to high	The view, from a rural gravel road, looks west toward the site. Buildings located along Route 1 at Carpenters Corner are within 1 mi of the easternmost sector site alternative. Route 1 is a State Trunk Highway.
	Wood/Pembina Historic Trail	Class C	Rural countryside predominantly consisting of flat cropland interspersed with swampy woodlots and grasslands	High	Viewer sensitivity high due to historic setting of trail
Rx-W					
	1	Class C	The landscape scene is flat, grassy, and agricultural. Bands of trees line the horizon and buildings in the northern portion are dominant landscape features	Low to mod	The view looks northeast toward the site from a rural road. Buildings are in the distance past the vast expanse of land
	2	Class C	A civic building and buildings in the distance are set in a flat, open landscape. Trees are in clusters. Utility poles and lines are in the far distance	Mod	The view, looking east toward the site, shows the Helgeland Township Hall. The view is from the intersection of rural roads
	3	Class C	The landscape scene is open farmland punctuated by rows of trees in the distance	Low to mod	The unobstructed view is from a rural road and looks northwest toward the site.

Source: The Duffey Company.

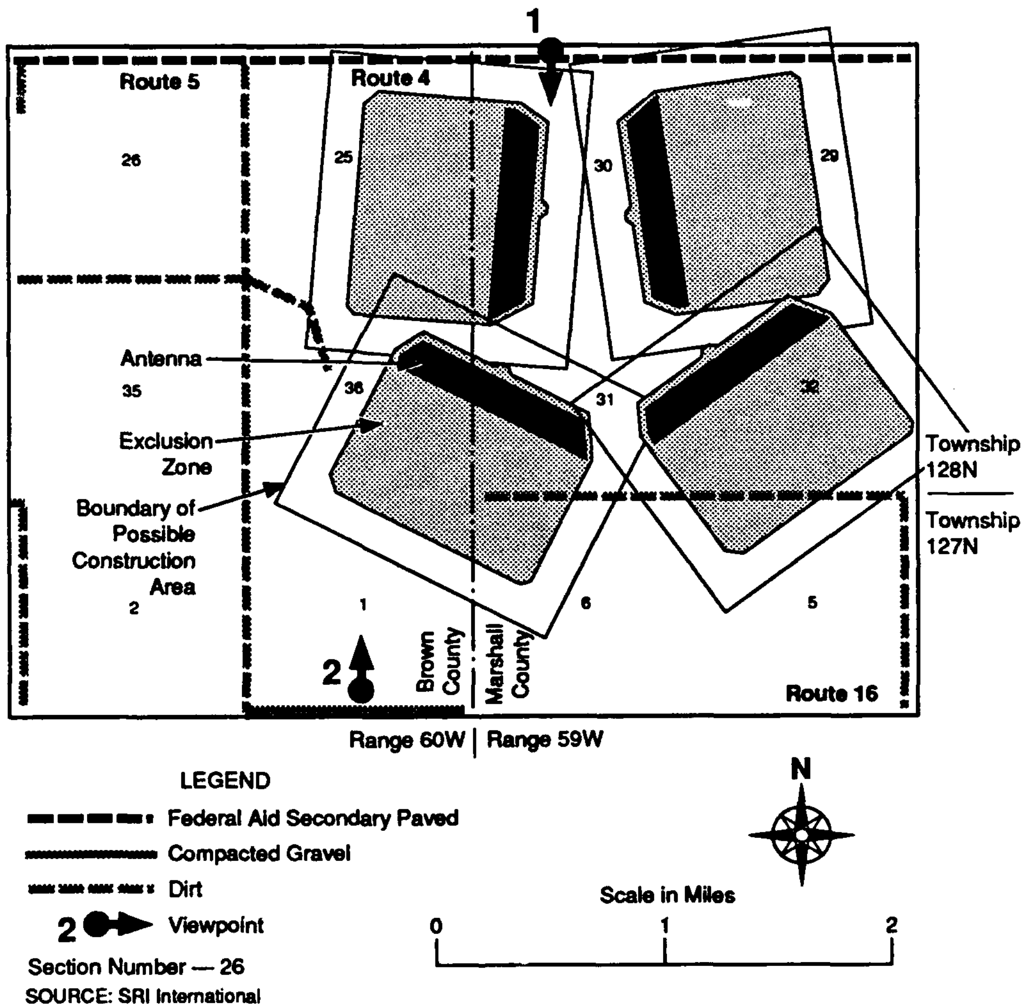
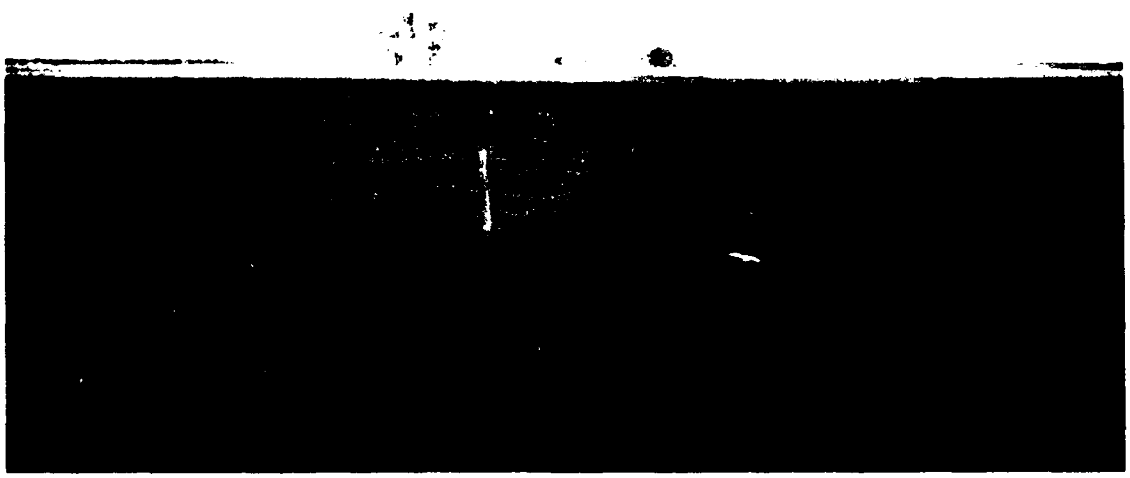


FIGURE 3.7.1 VIEWPOINT LOCATIONS: Tx–N

Viewpoint No. 1
Looking south from Route 4 (Section 30, T128N, R59W)

SOURCE: SRI International

Viewpoint No. 2
Looking north from a rural road (Section 1, T127N, R60W)



SOURCE: SRI International

FIGURE 3.7.2 PHOTOGRAPHS OF Tx–N

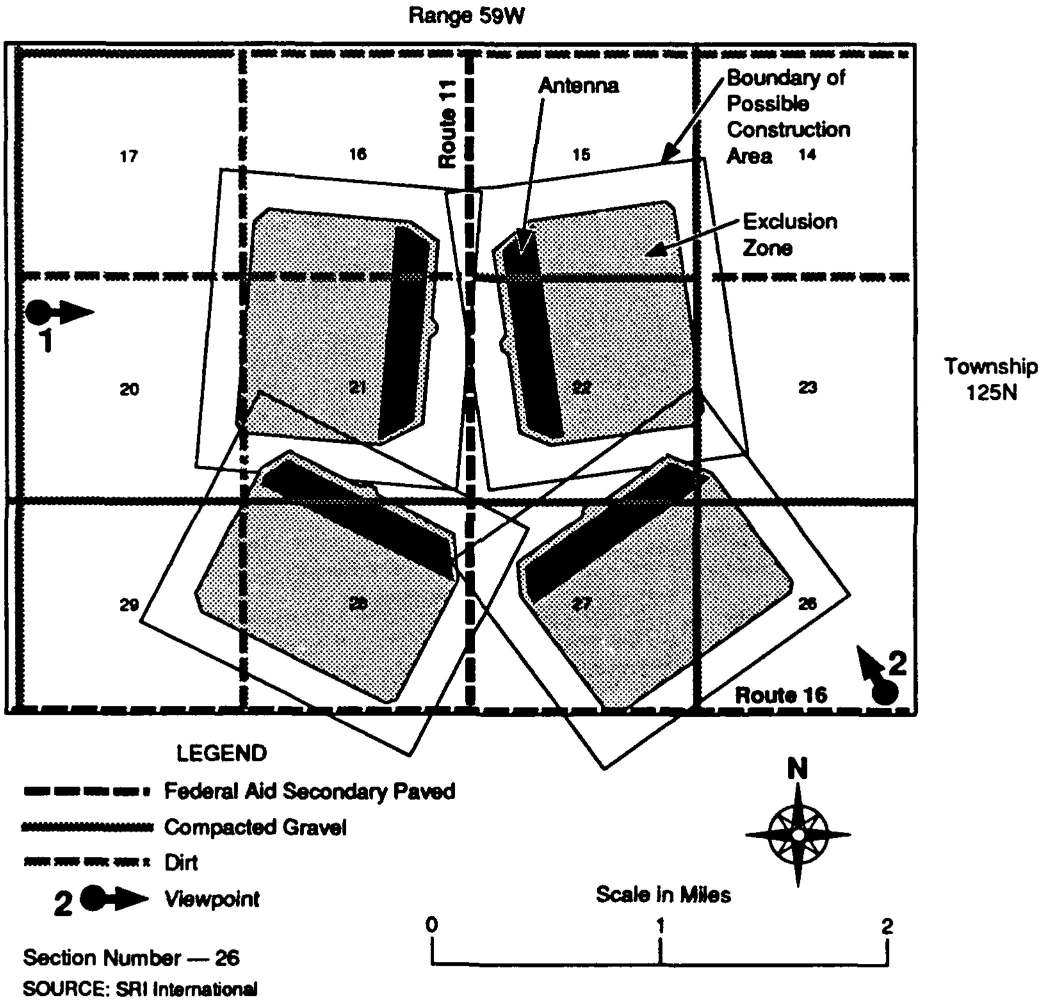
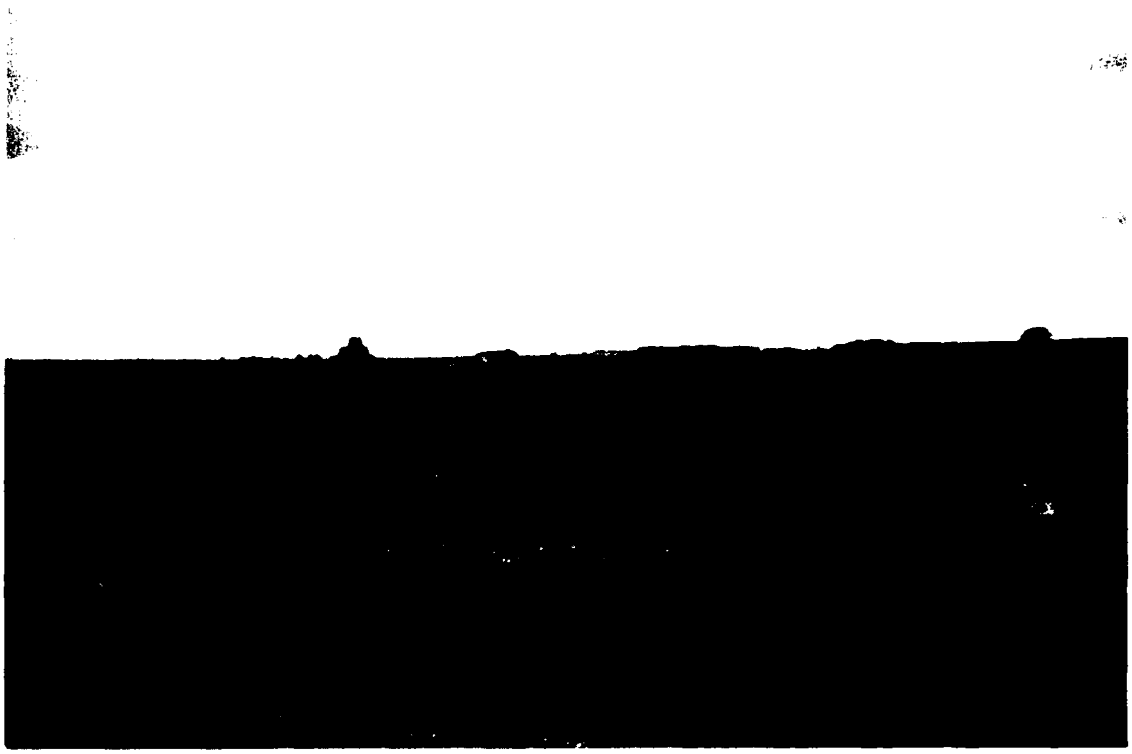


FIGURE 3.7.3 VIEWPOINT LOCATIONS: Tx–S

Viewpoint No. 1
Looking east from compacted gravel road (Section 20, T125N, R59W)



SOURCE: SRI International

Viewpoint No. 2
Looking northwest from Route 16 (Section 26, T125N, R59W)

SOURCE: SRI International

FIGURE 3.7.4 PHOTOGRAPHS OF Tx–S

3.7.3 Receive Study Area

3.7.3.1 Rx-E

Figure 3.7.5 shows the location of viewing points of the site from three different sides of Rx-E. Viewer sensitivity is low to moderate from the western and southern viewing points (Nos. 1 and 2) and moderate to high from viewing points northeast of the site along Route 1. The views from Route 1 are rated moderate to high because of higher public access and use within 0.5 mi of the site. Landscape features are common to the area (Class C) and do not exhibit any highly scenic or distinguished features (see Figure 3.7.6).

3.7.3.2 Rx-W

Figure 3.7.7 shows viewing locations to the west, south, and east of Rx-W, which is about 2 mi south of State Route 1, the primary public road in the area. Views of the site are available from gravel and dirt roads, from about eight private residences located within a 1-mi radius of the site layout, and from the Helgeland Township Hall. Viewer sensitivity is low to moderate from Viewpoints 1 and 3 on rural roads and moderate from Viewpoint 2 near Helgeland Township Hall. Landscape character is common to the geographic region (Class C), typified by broad, expansive croplands and clusters of trees (see Figure 3.7.8).

3.7.4 Power Supply

3.7.4.1 Transmit Site

Ten alternative links for powerlines for the transmit site were identified for analysis (see Figure 2.2.7). For the most part, transmission corridors parallel existing roads and other transmission lines. Landscape character in the general study area is characterized as flat to gently rolling upland plains that afford expansive views of grasslands and croplands from rural roads and residences. Most landscapes along the alternative corridors are common to the physiographic

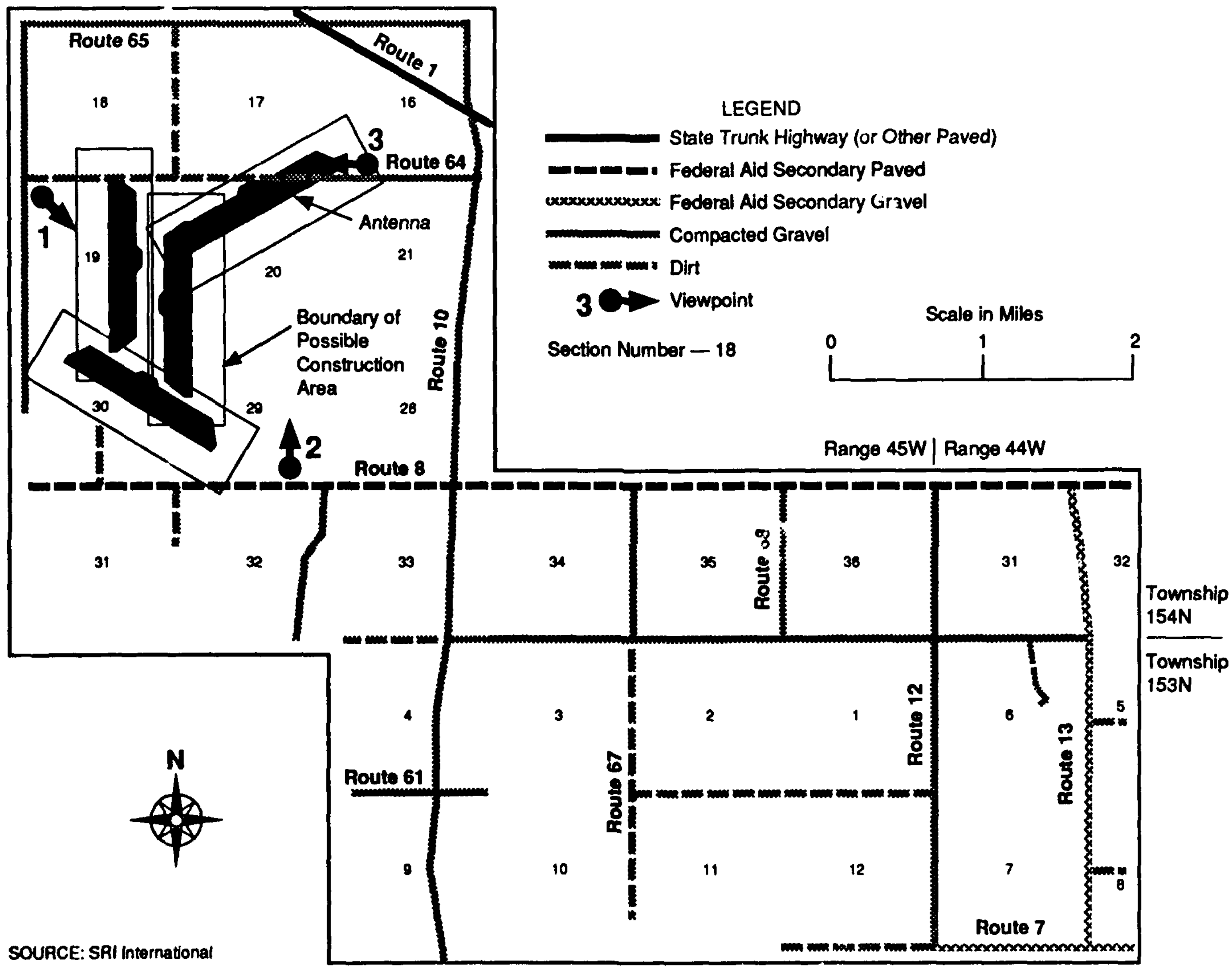


FIGURE 3.7.5 VIEWPOINT LOCATIONS: Rx-E

Viewpoint No. 1
Looking southeast from Route 64 (Section 19, T154N, R45W)

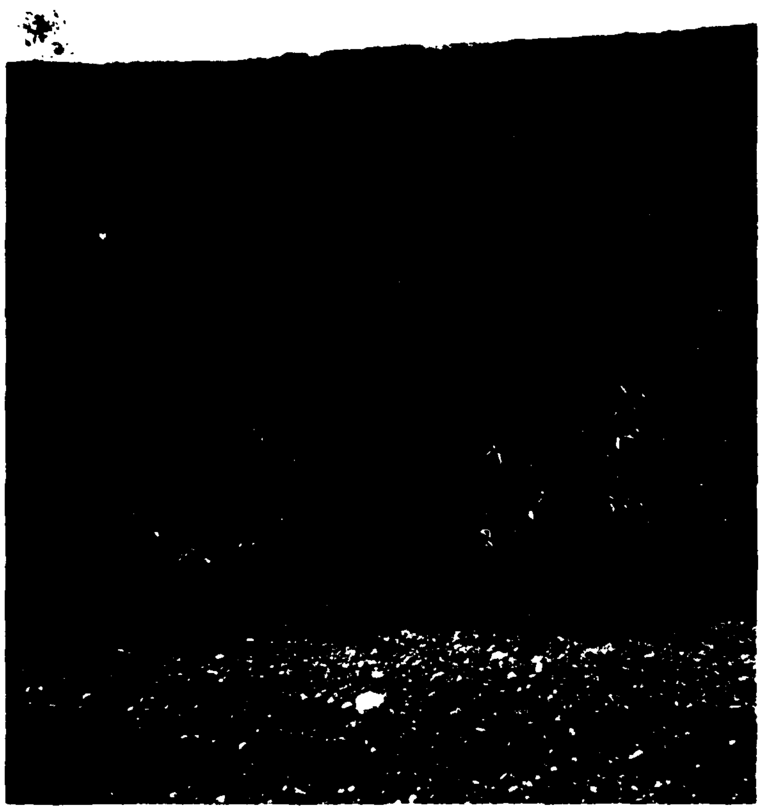
SOURCE: SRI International

Viewpoint No. 2
Looking north from Route 8 (Section 29, T154N, R45W)

SOURCE: SRI International

FIGURE 3.7.6 PHOTOGRAPHS OF Rx-E

Viewpoint No. 3
Looking west from Route 64 (Section 16, T154N, R45W)



SOURCE: SRI International

FIGURE 3.7.6 PHOTOGRAPHS OF Rx-E [Concluded]

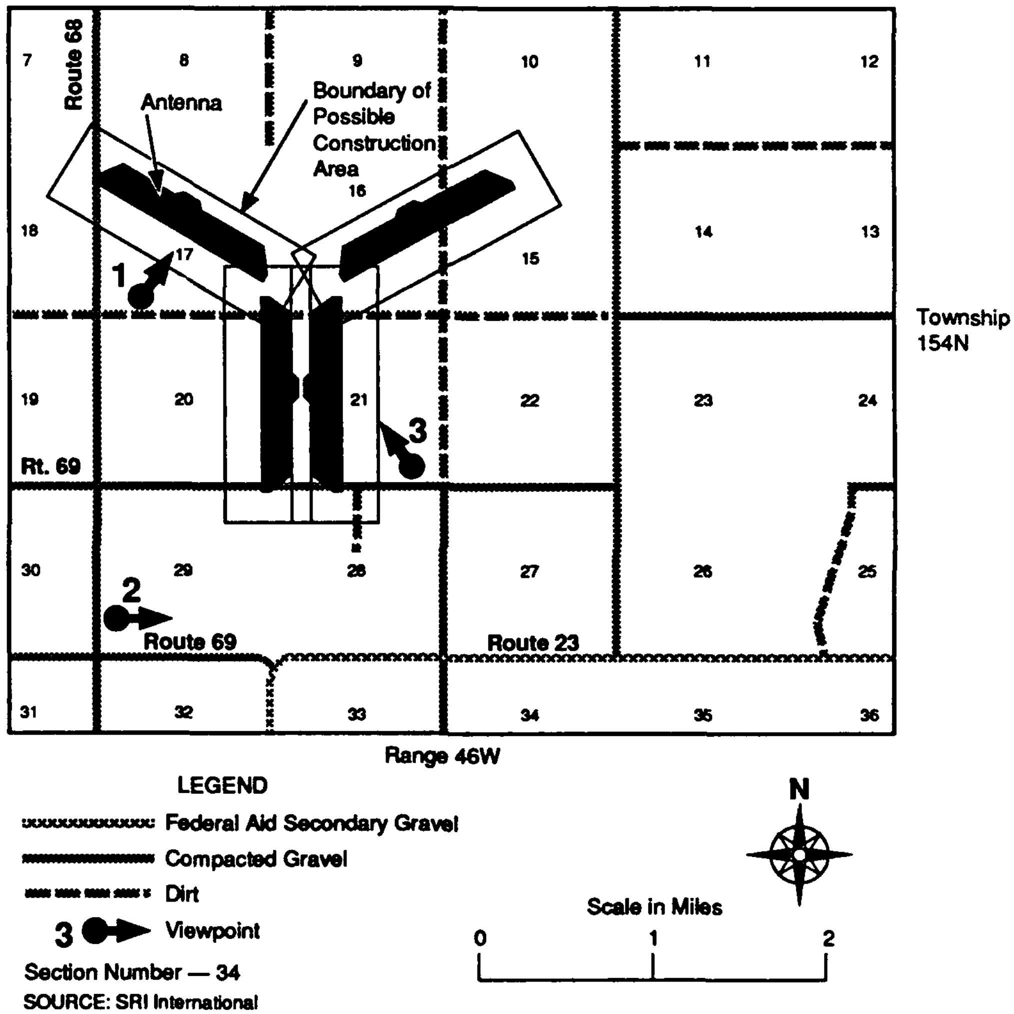


FIGURE 3.7.7 VIEWPOINT LOCATIONS: Rx–W

Viewpoint No. 1
Looking northeast from a dirt road near its intersection with Route 68 (Section 17, T154N, R46W)

SOURCE: SRI International

Viewpoint No. 2
Looking east toward Helgeland Town Hall from intersection of Routes 68 and 69 (Section 29, T154N, R46W)

SOURCE: SRI International

FIGURE 3.7.8 PHOTOGRAPHS OF Rx–W

Viewpoint No. 3
Looking northwest from rural road (Section 21, T154N, R46W)

SOURCE: SRI International

FIGURE 3.7.8 PHOTOGRAPHS OF Rx–W [Concluded]

region (Class C) and would be within the foreground view of secondary roads. The corridors do not cross parks or wildlife refuges. Visual features of some links result in above average scenic quality as summarized below:

Links 1 and 2: These links cross Mud Creek, an intermittent drainage, near the Groton Substation (Class B Landscape).

Link 4: Between Langford and Kidder, this link crosses three major drainages that have substantial topographic relief (Class B landscape).

Link 7: The northwestern portion of this corridor near Oakes, North Dakota, crosses glacial deposits that form low hills, breaklands, and ridges. That topography provides visual variety in an otherwise homogeneous setting (Class B landscape).

Links 8 and 9: The northern portions of these corridors include numerous small wetlands and ponds (Class B landscape).

3.7.4.2 Receive Site

Transmission line corridors for Rx-E parallel existing roads for their 13-15 mi length from either the Morris-Owen or Dakota Junction Substations. No parks or wildlife refuges are crossed. Landscapes along the alternative corridors are common to the region (Class C), consisting primarily of open croplands with little topographic relief. The northernmost corridor, which connects to the Dakota Junction substation, crosses a swampy, forested beach ridge area 4-5 mi east of Carpenters Corner (Class B landscape). The southern two corridors, which connect to the Morris-Owen substation, both cross the northern edge of Goose Lake Swamp and another swampy forested area roughly 5-7 mi west of Thief River Falls. Those two swamps are located on or adjacent to glacial beach ridges, thereby providing some topographic relief (Class B landscapes).

The 5-mi corridor connecting to the western receive CSA from the Radium Substation crosses landscapes offering some visual variety. The corridor crosses the Snake River, the south branch of the Snake River, and Highway 1 (Class B landscapes).

3.8 LAND USE

This subsection describes existing land use of the transmit and receive study areas and the alternative powerline corridors. Uses of the South Dakota and Minnesota study areas and the receive site powerline corridors were determined through field reconnaissances and contacts with local, state, and federal agencies. Uses of the transmit-site powerline corridors were inventoried from satellite data.

3.8.1 Transmit Study Area

Tx-N and Tx-S are located in agricultural areas of Brown and Marshall counties, South Dakota. Because there are no urbanized areas within the CSAs, this analysis is restricted to rural land use. Wheat, corn, and barley are the principal crops grown in the two counties. (South Dakota Agricultural Statistics Service, 1989) Acreage planted to each crop varies from year to year, but what dominates with about 50% of the acreage planted; approximately 20% is corn, and 10% is barley.

A small portion of the cropland in Brown and Marshall counties has been enrolled in the Conservation Reserve Program (CRP). The U. S. Department of Agriculture (USDA) administers this program to protect highly erodible cropland. Farmers enter into a 10-year contract to convert eligible land to permanent vegetative cover in return for annual payments from the USDA.

The study areas are divided into 1-mi square sections; each section contains 640 acres. The sections are grouped into townships 6 mi on a side. The boundaries of each section generally have a dirt, gravel, or paved road that forms a grid covering the landscape. Land ownership is generally by the section or portion thereof, with one-half (320 acres), one-quarter (160 acres), and one-

eighth (80 acres) sections being common parcel sizes. Private roads and fences separate individual fields and are typically oriented north-south and east-west in keeping with the township grid pattern. Residential land use at Tx-N and Tx-S is limited to scattered farm houses. Most farm houses in the area have barns, silos, and outbuildings nearby.Tx-N, located on Sections 29-32 of T128N, R59W; Sections 5 and 6 of T127N, R59W; Sections 25 and 35 of T128N, R60W; and Section 1 of T127N, R60W, is primarily pasture. (Metcalf & Eddy/Holmes & Narver, 1990E) Nearly 500 acres of CRP lands are included in the northern CSA, but none is located in the Tx-N preliminary site layout. The road network at Tx-N is not fully connected. Only two short dirt roads cross the site, and both terminate on site. Most section lines lack roads. The preliminary site layout includes no houses or substantial buildings.

Tx-S near Langford is primarily cropland used for wheat. The CSA contains approximately 326 acres enrolled in the CRP; most are included in the preliminary site layout area. Tx-S includes portions of Sections 14–17, 20–23, and 26–29 of T125N, R59W. A fully connected grid of dirt, gravel, or paved roads covers the area. The preliminary site layout covers six farmhouses, most of which have nearby outbuildings. Several other houses and farm buildings are nearby.

3.8.2 Receive Study Area

The CRS receive study area is located in agricultural areas of Pennington and Polk counties of Minnesota. Because there are no urbanized areas within the study area, this analysis is limited to rural land use. As described above for the transmit site, land is divided into 1 mi^2 sections grouped into townships containing 36 sections. Wheat and barley account for approximately 65% of the planted acreage in the two counties. (Minnesota Agricultural Statistics Service, 1989) Rx-E and Rx-W are predominantly agricultural, with a variety of grain crops and livestock operations. A considerable portion of the cropland in Pennington and Polk counties has been enrolled in the CRP. A maximum of 25% of the land in any one county can be enrolled in the CRP; this limit has been reached in both counties. Residential land use of Rx-E and Rx-W is limited to scattered farm houses. Most farm houses in the area have barns, silos, and outbuildings nearby.

Rx-E is approximately 50% cropland and 50% grazing land. (Metcalf & Eddy/Holmes & Narver, 1990E) Approximately 1,400 acres in the vicinity of the preliminary antenna layout is enrolled in the CRP. (USDA, Agricultural Stabilization and Conservation Service, 1989) These lands are not currently under cultivation and cannot be returned to cultivation before the CRP contracts expire (1996 at the earliest). Dirt and gravel roads occupy roughly 40% of the section lines at the site. Within the area covered by the preliminary site layout, two farmhouses with outbuildings and one isolated grouping of farm buildings are located.

Rx-W is approximately 85% cropland and 15% grazing land. (Metcalf & Eddy/Holmes & Narver, 1990E) Approximately 850 acres in the vicinity of the preliminary antenna layout shown in Figure 2.2.6 are enrolled in the CRP. (USDA, Agricultural Stabilization and Conservation Service, 1989) Therefore, these lands are not currently under cultivation and cannot be returned to cultivation before the CRP contracts expire (1996 at the earliest). Dirt and gravel roads occupy roughly 70% of the section lines at the site. Within the area covered by the preliminary site layout, there are three farmhouses with outbuildings and two isolated groups of farm buildings.

3.8.3 Power Supply

3.8.3.1 Transmit-Site

The land uses of the transmit-site powerline corridors was inventoried by analyzing multi-spectral satellite data from June 1989. The alternative powerline corridors for the CRS transmit site are dominated by agricultural uses. The percentage of cultivated fields within each link ranges from 37% for Link 7 to 66% for Link 2 (see Table 3.8.1). In addition 21-43% of each link's area is covered by grasslands, much of which is used as pasture. The lowest percentage of grassland is 20.8% for Link 5 and the highest percentage is 43.3% for Link 3. Thus, the percentage of land area which could be devoted to agricultural uses would range up to 61.5% for Link 5 and up to 94.4% for Link 9. Percentages for the other links would be between those extremes.

Table 3.8.1

LAND USE OF THE TRANSMIT-SITE POWERLINE CORRIDORS[a]

Link	Land Use (%)				
	Cultivated Fields	Pasture/ Dry Grass	Mixed Urban[b]	Water Bodies/ Standing Water[c]	Bare Ground
1	49.3	42.5	0.8	2.6	4.6
2	66.3	23.3	0.5	4.4	5.4
3	37.5	43.3	1.2	8.2	9.7
4	63.8	25.2	0.5	5.2	5.3
5	40.7	20.8	0.1	1.4	36.9
6	63.9	31.1	0.1	1.3	3.6
7	37.4	36.6	0.3	2.1	23.6
8	48.7	32.9	0.1	4.3	14.1
9	63.9	30.5	0.1	3.8	1.7
10	57.3	29.0	0.2	8.3	5.3

a - Based on satellite date recorded on June 18, 1989. Totals may not add to 100% due to rounding.

b - Includes vacant land and agricultural land scattered within urban areas.

c - This total should not be compared with wetlands acreage given in sections 3.7 and 4.8, which are based on hydrological, soil, and vegetation characteristics.

SOURCE: Hammon, Jensen, Wallen.

Urban uses are limited in the rural powerline study area. Cities and towns within or adjacent to the corridors include Groton and Huffton, South Dakota, for Link 1; Andover, South Dakota,

for Link 2; Amherst, South Dakota, for Link 3; Britton and Kidder, South Dakota, for Link 4; Nicholson and Cogswell, North Dakota, for Link 7; Havana, North Dakota, for Link 9; and Forman, North Dakota, for Link 10. The percentage of urban land area ranges from 0.1% for Links 5, 6, 8 and 9 to 1.2% for Link 3. The cities and towns of the area range in population form 80 (Amherst, SD) to 1,590 (Britton, SD) and consist primarily of residences with limited amounts of commercial, industrial, and government uses. Numerous rural farmhouses occur within the corridors. Isolated residences are not included in the percentage of urban land due to the limited spectral resolution of the satellite data.

Permanent and semi-permanent water bodies such as ponds, lakes, streams, reservoirs and fields covered by standing water account for 1.3-8.3% of the areas of the corridors. These percentages are probably exaggerated because 1989 was a relatively wet year and unusually large areas of standing water were present. Links 1, 5, 6, and 7 had water features over less than 3% of the area, while water features covered over 8% of Links 3 and 10. Links 2, 4, 8, and 9 contained water features over 3.8-5.2% of their areas.

Bare ground lacking substantial vegetative coverage accounted for a substantial portions of some links. This may represent fields which have been tilled with little subsequent crop growth, blowouts and dunes formed from wind erosion, or construction sites. Bare ground occurs over less than 10% of Links 1-4, 6, and 9-10. At Links 5 (36.9%), 7 (23.6%), and 8 (14.1%), much more bare ground occurs. The soil of Links 5 and 7 is particularly susceptible to wind erosion and blowouts and dunes may account for a sizable amount of the bare ground of those links.

3.8.3.2 Receive-Site

Land use of the three alternative powerline corridors for Rx-E and the single powerline corridor for Rx-W is predominantly agricultural. It is estimated that about 80% of the CRS receive study area is cultivated and a similar percentage of the powerline corridors is probably agricultural. (Metcalf & Eddy/Holmes &Narver, 1990J) The majority of farmland of the area is

planted with spring wheat, sunflowers, oats, barley, sorghum, alfalfa, soybeans, and sugar beets. Farmhouses are widely scattered along all of the corridors.

Urban uses are extremely limited within or adjacent to the powerline corridors. The largest city of the area is Thief River Falls (population 9,105), where the Morris Owen Substation is located. The easternmost 0.5 mile or so of the two corridors connecting to that substation are within an area of scattered industrial, commercial, and residential uses on the outskirts of Thief River Falls. The northern most of those two corridors is also adjacent to the Lanstad Church and Cemetery.

The corridor connecting Rx-E to the Dakota Junction Substation crosses two sets of railroad tracks and State Highway 32 about two miles west of that substation. The Hegland Cemetery is within the corridor about 10 mi west of the substation. The corridor also crosses State Highway 1 near the corridor's western terminus. Carpenters Corner, a very small residential area, is about 2,000 ft north of the western corridor's terminus.

The powerline corridor for Rx-W includes portions of the town of Radium and the Immanuel Church. Radium is a small residential area.

3.9 RECREATION

3.9.1 Transmit Study Area

The SDDGFP estimates that at least 52% of the state's residents participate in some form of recreational activity, based on a survey conducted in 1985 for the "South Dakota Comprehensive Outdoor Recreation Plan, 1987." The findings were segmented into geographic planning districts. The CRS transmit site was included in a ten-county area identified as District 4, Northeastern South Dakota, where the most popular recreational activities were bicycling, swimming, and jogging. Table 3.9.1 shows estimated recreational participation by activity in more detail. Hunting, a popular activity in rural areas, ranks eighth statewide; regional data are not available.

Table 3.9.1
ESTIMATED RECREATIONAL ACTIVITY
BY SOUTH DAKOTA RESIDENTS, 1985
(Occasions in 1,000s)

Activity	Statewide	Rank	Northeast South Dakota	Rank
Bicycling	10,281	1	1,484	1
Swimming, beach	4,774	3	552	2
Jogging	3,582	4	458	3
Swimming, pool	7,074	2	408	4
Softball	2,708	7	350	5
Golfing	2,940	5	342	6
Power boating	1,912	12	289	7
Picnicking	2,870	6	287	8
Tennis	1,252	15	243	9
Sledding	2,193	11	225	10

Source: South Dakota Dept. of Game, Fish, and Parks, Division of Parks and Recreation, 1987

Northeastern South Dakota, known as the Glacial Lakes Region, has seven state parks and eight recreational areas that are the only public land areas designated for family recreational outings and vacations, allowing for camping, fishing, hiking, and swimming as well as various other activities. No state parks or recreational areas are located in the vicinity of the transmit study area. Fort Sisseton State Historical Park—located approximately 15 mi to the east, near the town of Eden—is the closest state park to the southern transmit CSA. Renzienhausen Slough Game Production Area, roughly 3 mi to the south of the northern transmit CSA, and Sand Lake National Wildlife Refuge, about 10 mi to the west of that CSA, are the closest wildlife management areas.

Hunting is popular in northeastern South Dakota, and public hunting lands alone are unable to support the high demand. A high percentage of these activities occur on private land. The SDDGFP encourages private land owners to participate in game production programs allowing hunting on their property. Acreage of game production areas in 1988 totaled approximately

9,500 in Brown County, 16,200 in Day County, and 21,000 in Marshall County. In recent years, however, closure of private land to hunting due to landowner liability and other factors has been an increasing problem. Wildlife Management Areas are also often made available for local hunting. The Renzienhausen Slough Game Production Area, 3 mi south of the northern CSA, is open to hunting.

3.9.2 Receive Study Area

In the four-county area of Marshall, Pennington, Polk, and Red Lake, the Minnesota Department of Natural Resources, Office of Planning, estimates that over 6.4 million occasions of recreational activity occur annually. The most popular recreational activities in this area are walking and hiking, followed by biking, driving, and baseball. Walking/hiking represents 30% of all recreational activity, biking 22%, driving 13%, and baseball 10%. Table 3.9.2 identifies the 10 most frequent recreational activities by the number of occasions.

Table 3.9.2
RECREATIONAL ACTIVITY IN MARSHALL, PENNINGTON, POLK, AND RED LAKE COUNTIES, MINNESOTA
(Occasions in 1,000s)

Activity	Marshall	Pennington	Polk	Red Lake	Total
Walking/hiking	73	396	475	994	1,938
Biking	29	329	1,084	---	1,442
Driving	151	232	368	97	848
Baseball/softball	---	29	591	---	620
Swimming	---	106	102	---	208
Boating	---	---	185	---	185
2,3, & 4 wheeling	---	181	5	---	186
Net Sports	31	99	15	---	145
Field events	---	18	99	---	117
Hunting	---	94	---	---	94

--- means data is unavailable

Source: Minnesota Dept. of Natural Resources, Office of Planning, 1986.

The demand for hunting areas is not as strong in Minnesota as it is in South Dakota. Unlike in South Dakota, the Minnesota Department of Fish, Game, and Parks does not have a formal game protection program that encourages hunting on private property.

Few state parks and recreational areas occur in the vicinity of the receive CSAs. Old Mill State Park is located 15 mi north of the western receive CSA. The Agassiz National Wildlife Refuge near the town of Holt is located 25 mi northeast of the eastern receive CSA.

3.9.3 Power Supply

The frequency and types of recreational activities pursued in and near the power supply corridors for the CRS transmit and receive sites are generally the same as described above for Northeastern South Dakota and Northwestern Minnesota.

3.10 SOCIOECONOMICS

This subsection describes the socioeconomic setting of the alternative CRS sites and powerline corridors, including population, housing demand, employment, personal income, and finances of counties and school districts. For socioeconomic attributes, the effects of CRS would extend beyond the limits of the antenna sites and CSA. The counties expected to experience most of the socioeconomic impacts are listed in Table 3.10.1.

Both the transmit and receive study areas can be broadly characterized as sparsely settled, rural farmland on very level terrain. The principal land use is agriculture; more than 90% of the total land area is designated as farmland. The average population density is less than 10 persons per mi^2. The major urbanized area near the South Dakota transmit study area is Aberdeen (Brown County), 35 mi southwest of Tx-S. Thief River Falls is the largest urbanized area near the Minnesota receive study area, lying 15 mi east; Crookston is 20 mi south.

Table 3.10.1
COUNTIES IN THE SOCIOECONOMIC
STUDY AREAS FOR CRS

Study Area	Counties
CRS transmit study area	Brown, SD Day, SD Marshall, SD
CRS receive study area	Marshall, MN Pennington, MN Polk, MN Red Lake, MN

Source: SRI International

Those cities are most likely to realize the largest absolute economic effects from construction and operation of the proposed installations. Some of the smaller communities near the potential sites, however, are likely to realize larger relative effects (that is, the greatest proportional changes). Of the seven counties that CRS construction and operation would likely affect, only Pennington County in Minnesota and Brown County in South Dakota have more than one-half of the population residing in urbanized areas. Grand Forks, North Dakota (population 43,765), is a sizable metropolitan area that adjoins the Minnesota study area (State of North Dakota, 1989). Grand Forks, about 30 mi southwest of the receive study area, is expected to experience some socioeconomic effects of CRS. Because of its distance from the receive site and its relatively large size, however, any effects are likely to be small and are not analyzed in this EIS.

3.10.1 Transmit Study Area

The CRS transmit study area is located in northeastern South Dakota. Tx-N is located on the border of Brown and Marshall counties. Tx-S is located in southwestern Marshall County.

3.10.1.1 Employment and Income

The total nonfarm employment for all industries in the tricounty area was 19,190 in 1988. Brown County is responsible for generating the majority of the nonfarm employment in the region, accounting for 83% of the labor market. (South Dakota Department of Labor, 1989) Wholesale and retail trade is the largest employer in the area, supporting 28% of jobs in 1988. Services, employing 23%, government 19%, and manufacturing industries 18%, also play an important role in the regional economy (See Table 3.10.2). Although the level of government employment has not changed much during the 1980s, the services industry has become a more significant player in regional employment. Manufacturing industries have continued to steadily decline in percentage of total employment since the early 1980s, a trend that is likely to continue into the 1990s.

Table 3.10.2
1988 NONFARM EMPLOYMENT AT CRS TRANSMIT STUDY AREA

	Employment by County			
Industry	Brown	Day	Marshall	Total
Construction	576	62	39	677
Manufacturing	2,814	303	305	3,422
Transport & Utilities	597	102	32	731
Trade	4,705	470	261	5,436
F.I.R.E.[a]	751	86	45	882
Services	3,850	431	193	4,474
Government	2,651	544	373	3,568
Total	15,944	1,999	1,248	19,190

[a] Finance, insurance, and real estate

Source: South Dakota Department of Labor, Labor Market Information Center, 1990.

Agriculture plays an important role in the regional economy. Wheat and corn are the most common crops in production. Direct agricultural employment in the tricounty area was 3,428 in 1980, spread among the three counties as follows: Brown, 1,583; Day 1,054; and Marshall, 791. (U.S. Bureau of the Census, 1986B)

Personal income in the three counties in the vicinity of the transmit site is summarized in Table 3.10.3. Farm income was $71.7 million or approximately 11% of the region's income in 1987. Farm income fluctuates considerably from year to year as crop and livestock prices vary.

Table 3.10.3
PERSONAL INCOME OF NORTHEASTERN SOUTH DAKOTA
(Millions of Dollars)

County	Farm	NonFarm	Total
Brown	34.0	462.3	496.3
Day	18.6	71.1	89.7
Marshall	19.1	45.7	64.8
Total	71.7	579.1	650.8

Source: U. S. Department of Commerce
Bureau of Economic Analysis, 1986.

Nonfarm personal income is expected to grow at the rate of inflation as measured by the consumer price index. Future farm income is expected to fluctuate from year to year; for this study, it is assumed to remain at the 1987 level, which is near the high end of the range for 1982 through 1987. (U.S. Department of Commerce, 1989) Based on an inflation rate of 4.8% annually (The WEFA Group, 1989), nonfarm personal income in the region would grow to $804 million in 1994, and total personal income would be approximately $876 million.

3.10.1.2 Population and Housing

Over the past two decades, population in northeastern South Dakota has tended to move from the rural to the urbanized areas. All urbanized counties gained population in amounts ranging from 0.1-20% between 1970 and 1980. Between 1980 and 1988, however, total population among all of the counties declined, ranging from 0.2-9.3%. Much of the decline resulted from depressed economic conditions in agriculture and manufacturing industries. Population in the tricounty area around the CRS transmit site alternatives totaled 49,600 in 1988, declining by 1.8% since 1980. Population density equaled 13.8 persons per mi^2 in 1988. Table 3.10.4 shows the populations of all counties in the study areas.

Table 3.10.4
COUNTY POPULATIONS AT CRS TRANSMIT STUDY AREA: 1980 AND 1988

County	Population 1980	Population 1988	Percentage Change
Brown	36,962	36,900	-0.2%
Day	8,133	7,800	-4.1%
Marshall	5,404	4,900	-9.3%
Total	50,499	49,600	-1.8%

Source: U. S. Bureau of Census, 1983 and Sales and Marketing Management, 1989.

Tx-S in the southwestern corner of Marshall County is located 3 mi west of the town of Langford, population 307, and 4 mi southeast of the town of Claremont, population 180. Marshall County population has declined 9.3% since 1980, from 5,404 to 4,900 in 1988, with a density of 5.8 persons per mi^2.

Tx-N is located on the border of Brown and Marshall counties, 4 mi south of the state border with North Dakota and 6 mi southwest of the town of Helca, population 435. Another residential community in the vicinity of the site is Amherst (population 80), 7 mi to the south. The population of Brown County has remained relatively unchanged since 1980, declining by only 0.2% to a total of 36,900 in 1988. The majority of Brown County's population, however, is clustered in and around the city of Aberdeen, population 25,800, located approximately 36 mi southwest of Tx-N. The population density of Brown County as a whole was 21.4 persons per mi^2 in 1988. The population density around the northern CSA, however, is apparently significantly less than that of the county-wide average.

As shown in Table 3.10.5, housing units in the tricounty area totaled 20,084 in 1980, with 18,304 units occupied and 1,780 units vacant. The total median number of occupants per household was 2.76. Marshall County had roughly 10% of total housing units, totaling 2,234 in 1980, of which 13.6% or 267 were vacant. (U.S. Bureau of Census, 1983)

Table 3.10.5
1980 POPULATION AND HOUSING DATA - CRS TRANSMIT STUDY AREA

County	Total Population	Total Housing Units	Total Occupied Units	Total Vacant Units	Average Persons Per Unit
Brown, SD	36,962	14,504	13,357	1,147	2.77
Day, SD	8,133	3,346	2,980	366	2.73
Marshall, SD	5,404	2,234	1,967	267	2.75
Total	50,499	20,084	18,304	1,780	2.76

Source: U.S Bureau of the Census, 1983.

Based on the assumption that the median household size remained the same between 1980 and 1988, the demand for housing in 1988 would have declined by 344 units (see Table 3.10.6). Of the total, Marshall County would account for 54% of the decline or a decrease of 185 occupied housing units. Assuming few units were demolished between 1980 and 1988, the total number of vacant units could exceed 2,100.

Table 3.10.6
1988 POPULATION AND HOUSING DATA-
CRS TRANSMIT STUDY AREA

County	Total Population	Average Persons Per Unit	Occupied Units 1980	Occupied Units 1988	Occupied Units 1980-1988 Change
Brown, SD	36,900	2.77	13,357	13,321	-36
Day, SD	7,800	2.73	2,980	2,857	-123
Marshall, SD	4,900	2.75	1,967	1,782	-185
Total	49,600	2.76	18,304	17,960	-344

Source: U.S Bureau of the Census, 1983 and Sales and Marketing Management, 1989.

According to the AAA Travel Guide, the tricounty area has 270 AAA-affiliated lodging units—that is, motel rooms (AAA, 1990).

3.10.1.3 Fiscal Setting

County governments and school districts receive much of their revenues from property taxes levied on privately owned real property. Tx-N covers portions of Brown County, which has an assessed valuation of $247 million for all land, and Marshall County, which has a total assessed valuation of $117 million. The Brown County portion of the site is in the Helca School District,

and the Marshall County portion is in the Britton School District. Assessed value is approximately $22 million in the Hecla School District and $68 million in the Britton School District.

Tx-S is located in Marshall County, which has a total assessed valuation of $117 million. (R. Mette, 1989) It is also located in the Langford School District, which includes portions of three counties. Assessed value of real property in the district is $41 million.

3.10.2 Receive Study Area

Rx-E and Rx-W are located in northwestern Minnesota. Rx-W is located in Polk County, while Rx-E is located in Pennington County. (Table 3.10.1 identifies the counties included in the socioeconomic study area.)

3.10.2.1 Employment and Income

As shown in Table 3.10.7, the four-county receive study area had an average nonfarm employment level of 17,649 in 1988. (Minnesota Department of Jobs and Training, 1989) The largest concentration of the labor force is in Polk County, representing 54% of the regional employment. Wholesale and retail trade was the largest industry employer in the area in 1988, accounting for 28.5% of the job market. Service industries and government each represented 25% of total employment, and manufacturing employed only 12.3% of the labor force in 1988.

Agriculture plays an important role in the regional economy of the receive study area. Wheat and corn are the most common crops in production. Direct agricultural employment in the four-county area was 4,605 in 1980, spread among the four counties as follows: Marshall 1,436; Pennington 661; Polk 2,234; and Red Lake 274.

Table 3.10.7
1988 NONFARM EMPLOYMENT,
CRS RECEIVE STUDY AREA

Industry	Employment by County				Total
	Marshall	Pennington	Polk	Red Lake	
Construction	79	92	234	37	442
Manufacturing	119	809	1,140	108	2,176
Transport & utilities	44	155	295	40	534
Trade	593	1,724	2,468	249	5,034
F.I.R.E.[1]	127	173	357	49	706
Services	311	1,139	2,772	133	4,355
Government	715	1,097	2,222	368	4,402
Total	1,988	5,189	9,488	984	17,649

[1]Finance, insurance, and real estate

Source: Minnesota Dept. of Jobs and Training, Research and Statistics Office, 1989.

Personal income in the four counties in the vicinity of the receive study area is summarized in Table 3.10.8. Farm income was $142.2 million or approximately 17% of the region's income in 1987. Farm income fluctuates considerably from year to year as crop and livestock prices vary.

Table 3.10.8
1987 PERSONAL INCOME IN REGION NEAR CRS
RECEIVE STUDY AREA
(Millions of Dollars)

County	Farm	Nonfarm	Total
Marshall	46.4	110.6	157.0
Pennington	13.3	159.1	172.4
Polk	68.6	389.2	457.8
Red Lake	13.9	44.7	58.6
Total	142.2	703.6	845.8

Source: U. S. Department of Commerce, 1989.

Nonfarm personal income is expected to grow at the rate of inflation as measured by the consumer price index. Future farm income is expected to fluctuate from year to year; for this study, it is assumed to remain at the 1987 level, which is near the high end of the range for 1982 through 1987. (U.S. Department of Commerce, 1989) Assuming inflation at 4.8% annually (The WEFA Group, 1989), nonfarm personal income in the region would grow to $977 million in 1994, and total personal income would be approximately $1,119 million.

3.10.2.2 Population and Housing

Rx-E and Rx-W are located along the northern border of Pennington and Polk counties, Minnesota. Rx-W is located in Polk County, which had a population of 33,700 in 1988, a decline of 3.3% since 1980. Rx-E is located in Pennington County, which had a population of 14,600 in 1988, a decline of 3.9% since 1980. The Marshall County population was 12,300 in 1988, a decline of 5.6% since 1980 (See Table 3.10.9). The largest urban area near the sites is Thief River Falls (population 9,105), the Pennington County seat, which is located 8 mi east of the receive study area. Crookston (population 8,628), the Polk County seat, is located 20 mi south of the receive study area.

Table 3.10.9
POPULATIONS OF COUNTIES NEAR CRS RECEIVE STUDY AREA

	Population		Percentage
County	1980	1988	Change
Marshall	13,027	12,300	-5.6%
Pennington	15,258	14,600	-4.3%
Polk	34,844	33,700	-3.3%
Red Lake	5,471	5,100	-6.8%
Total	68,600	65,700	-4.2%

Source: U.S. Bureau of the Census, 1983; Sales & Marketing Management, August 7, 1989.

Rx-E is located 8 mi west of Thief River Falls. Other residential communities are Viking (population 129) 4 mi north of the CSA and Rosewood (population 30) 8 mi northeast of the CSA, both located in Marshall County. The population density of Pennington County was 23.6 persons per mi^2 in 1988.

Rx-W is located 8 mi southeast of the town of Warren, population 2,105, in Marshall County. Other residential concentrations are Angus (population 60) 6 mi southwest of the site and Euclid (population 160), 10 mi south of the site. The population density of Polk County as a whole was 17 persons per mi^2 in 1988. Density in the vicinity of the western receive CSA is apparently much less than the county-wide average.

Total housing units in the four-county area totaled 26,724 in 1980, of which 23,872 units were occupied and 2,852 units were vacant (see Table 3.10.10). The median number of occupants per household was 2.87. Polk County accounted for 51% of total housing with 13,659 units in 1980, of which 11% or 1,505 were vacant. Pennington County accounted for 22% of total housing with 5,945, of which 508 or 8.5% were vacant. Marshall County had 5,115 housing units in 1980 with a 12.8% vacancy rate, and Red Lake County had 2,005 units and a vacancy rate of 9.3%. (U.S. Bureau of the Census, 1983) No housing data have been tabulated since the 1980 Census of Population and Housing Characteristics report. If it is assumed that the median household size remained the same between 1980 and 1988, the demand for housing in the four-county area would have declined by 1,028 units or 4.3% during that period. Of the total, Polk County would account for 40% of the decline, or a decrease of 412 occupied housing units. Table 3.10.11 shows the estimated vacancies occurring between 1980 and 1988. Adding 1,000 vacant units to the vacancies in 1980 implies that the four counties have more than 3,800 vacant housing units.

Table 3.10.10
1980 POPULATION & HOUSING DATA
CRS RECEIVE STUDY AREA

County	Total Population	Total Housing Units	Total Units	Total Vacant Units	Average Persons Per Unit
Marshall	13,027	5,115	4,463	652	2.92
Pennington	15,258	5,945	5,437	508	2.81
Polk	34,844	13,659	12,154	1,505	2.87
Red Lake	5,471	2,005	1,818	187	3.01
Total	68,600	26,724	23,872	2,852	2.87

Source: U.S. Bureau of the Census, 1983.

Table 3.10.11
1988 POPULATION AND HOUSING DATA-
CRS RECEIVE STUDY AREA

County	Total Population	Average Persons Per Unit	Occupied Units 1980	Occupied Units 1988	Occupied Units 1980-1988 Change
Marshall	12,300	2.92	4,463	4,212	-251
Pennington	14,600	2.81	5,437	5,196	-241
Polk	33,700	2.87	12,154	11,742	-412
Red Lake	5,100	3.01	1,818	1,694	-124
Total	65,700	2.87	23,872	22,844	-1,028

Source: U.S. Bureau of the Census, 1983 and Sales & Marketing Management, 1989.

According to the AAA Travel Guide, 961 AAA affiliated lodging units (motel rooms) are within a 35-mi radius from the receive site search areas (AAA, 1990). Of this total, 755 units or 80% are located in Grand Forks, North Dakota.

3.10.2.3 Fiscal Setting

Rx-E is in Pennington County, which has an assessed valuation of $77 million. The site is in the Thief River Falls School District which includes portions of Pennington and Red Lake counties. Total assessed value in the district is approximately $52 million.

Rx-W is located in Polk County, which has a total assessed valuation of approximately $227 million. (U. S. Bureau of the Census, 1989) The CSA is also located in the Warren School District, which includes portions of Polk and Marshall counties. Total assessed value in the district is approximately $103 million.

3.11 TRANSPORTATION

3.11.1 Overview

This section and Section 4.12, except for Sections 3.11.4 and 4.12.4 on the CRS powerline study areas, summarize the results of Technical Study 3, Central Radar System Over-the-Horizon Backscatter Radar Program, Transportion prepared by Metcalf & Eddy/Holmes & Narver (1990C).

The South Dakota Department of Transportation (DOT) requires an Approach Permit for driveways accessing state-numbered roads. In Brown and Marshall counties, no permit requirements exist for county or township roads.

The Minnesota DOT requires a State Entrance Permit for driveways or roads accessing state highways. Polk and Pennington counties have weight-bearing limitations for county-maintained

roads during the spring. Polk County requires that new access to a county road be authorized by the County Highway Department. Additionally, if a new road crosses a regional watershed ditch or a county drainage ditch, approval from the Watershed District Engineer or the County Ditch Engineer is necessary. No permits are needed to access a county road in Pennington County.

The roads of the transmit and receive CSAs fall into three categories: paved roads with two 12-ft-wide bituminous lanes and sometimes unpaved shoulders; compacted gravel roads that are typically 16-24 ft wide; and dirt roads with minimal, if any, improvements and one travel lane.

At the transmit CSAs, Federal Aid Secondary paved and compacted gravel roads, county-maintained gravel and dirt roads, and local gravel and dirt roads are present. At the receive CSAs, State Trunk Highways, Federal Aid Primary paved roads, Federal Aid Secondary roads, County State Aid paved and gravel roads, county gravel roads, and township and section-line dirt roads are present.

3.11.2 Transmit Study Area

3.11.2.1 Tx-N

Within the northern transmit CSA, there are 4 mi of paved road, 1.2 mi of gravel road, and 7.8 mi of dirt roads. Each road of this CSA is described below (also see Figure 2.2.2):

Brown County Route 5/Marshall County Route 4 — This is a bituminous paved Federal Aid Secondary road that provides access to Kidder to the east and Hecla to the west. It is on the northern boundary of the CSA. Average Daily Traffic (ADT) is 54.

State Route 10 — Located about 3 mi south of the CSA, this State and Federal Aid Secondary paved road provides access to U.S. 281 to the west and Britton to the east. ADT is 735.

Unnamed road at boundary between Townships 127N and 128N—This dirt road is maintained by Marshall County, crosses the CSA for 2 mi and terminates in the CSA. ADT is unknown, but is estimated at much less than for Brown County Route 5/Marshall County Route 4, which has an ADT of 54.

Unnamed gravel road at boundary between Sections 1 and 12 of T127N, R60W—This gravel road is maintained by Brown County, crosses the CSA for 1 mi, and terminates in the CSA. ADT is has not been measured and is estimated at much less than for Brown County Route 5/Marshall County Route 4.

Unnamed gravel road on western sectionline of Sections 25 and 36, T128N, R60W, and Section 1, T127N, R60W—This road has a compacted gravel and dirt surface and is maintained by Brown County. It connects to Route 10 about 3 mi south of the CSA. ADT has not been measured, but is expected to be much less than for Brown County Route 5/Marshall County Route 4.

3.11.2.2 Tx-S

The southern transmit CSA has 7 mi of paved road, 11 mi of compacted gravel road, and 9 mi of dirt road. There is a road on each section line of the CSA. The most important roads of the CSA are Route 16, which is on the southern boundary of the CSA, and Route 11, which is oriented north-south and bisects the CSA (see Figure 2.2.3). The roads of the CSA are described below:

Marshall County Route 16 — This bituminous paved road is oriented east–west at the southern edge of the CSA and provides access to Langford to the east and Route 37 to the west. It is a Federal Aid Secondary road and has ADT of 237.

Marshall County Route 11 — This bituminous paved road is oriented north–south and intersects Route 16 at the southern boundary of the CSA and Route 10 about 13 mi north of

the CSA. It provides access to Amherst, about 6 mi north of the CSA. ADT ranges between 76-78.

Other roads — Each section line within the CSA has a gravel or dirt surface road. Those roads form a complete road grid at 1-mi intervals across the CSA. All of those roads are maintained by Marshall County. ADTs have not been measured, but are expected to be less than that of Route 11, or below 76.

3.11.2.3 Traffic Growth

Growth in traffic volumes at CRS transmit study area and in the area as a whole during the past few years has been very small. The South Dakota DOT does not expect significant growth in traffic over the next 20 years.

3.11.3 Receive Study Area

3.11.3.1 Rx-E

Within the eastern receive CSA, there are about 9 mi of paved road, about 28 mi of gravel road, and about 10 mi of dirt road (see Figure 2.2.5). Many of these roads are south of Route 8, and the proposed CRS receive site is north of Route 8. Therefore, this section investigates only those roads within the portion of the CSA between Routes 1 and 8, which form a very incomplete grid. Each of those roads is described below:

Route 8 — This County State Aid paved road traverses the CSA from east to west, 1 mi north of the boundary between Townships 153 and 154 North. It provides access to Thief River Falls to the east and Route 23 to the west in Polk County. ADT is 75.

State Highway 1 — This is a paved State Trunk Highway that is oriented northwest–southeast and crosses the northeastern corner of the CSA. It provides access to Warren to

the west and Thief River Falls to the east. It is a Federal Aid Primary road and the most important road in the vicinity of the CSA. ADT is 690.

Route 10 —This is a compacted gravel Federal Aid Secondary and County State Aid road which is oriented north–south. It is on the eastern boundary of the northwestern portion of the CSA and connects to Route 1 in the north and Route 8 in the south. ADT is 60.

Route 65 — This east–west oriented county dirt road is located on the northern boundary of the CSA. It connects to Route 10 and State Highway 1 and has ADT of 20.

Unnamed road on western boundary of CSA —This compacted gravel road extends southward for 2.5 mi south of Route 10 and terminates at that spot. ADT has not been measured, but because of the dirt road surface is expected to be much less than that of Route 10, or below 60.

Route 64 — This county gravel road extends westward from Route 10 for 1 mi and then changes to a dirt road and continues westward to the western boundary of the CSA, where it intersects the unnamed gravel road. ADT east of the CSA is 70.

Unnamed dirt road — This dirt road on the border between Sections 17 and 18, T154N, R45W, is 1 mi long and connects Routes 64 and 65. ADT has not been measured, but because of the dirt road surface is estimated at less than for Routes 65 and 64, or below 20.

3.11.3.2 Rx-W

The western receive CSA contains approximately 19.5 mi of gravel road and 10 mi of dirt road (see Figure 2.2.6). All roads are on section lines and form a 70% grid over the study area. Those roads and other important roads in the vicinity are described below:

State Highway 1 — This paved two-lane road is located 2 mi north of the CSA and provides access to Warren and Thief River Falls. ADT in this area is 630.

Route 68 — This County State Aid compacted gravel road is oriented north–south. It provides local access to Helgeland Township. ADT is 75.

Route 69 — This County State Aid compacted gravel road is oriented east–west and is located on the border between Sections 19 and 30, and Sections 29 and 32 of T154N, R46W. It provides local access. ADT is 95.

Route 23 — This compacted gravel County State Aid road connects to the eastern terminus of Route 69 and continues eastward across the CSA and southward out of the CSA. ADT is 95.

Other roads — Many gravel and dirt roads follow section lines to form an incomplete grid across the CSA. ADTs have not been measured, but are expected to be below traffic volumes on the numbered routes described above, or below 75.

3.11.3.3 Traffic Growth

In the vicinity of the CRS receive study area, the Minnesota DOT projects an annual increase in ADT volumes of 1% or less.

3.11.4 Power Supply

3.11.4.1 Transmit Site

The major roads of the South Dakota portion of the transmit-site powerline study area are U.S. Highway 12 and State Routes 10, 27, and 37. U.S. Highway 12 is a four-lane paved road which connects to Interstate 29 near Summit, South Dakota, and to U.S. Highway 281 at Aberdeen, South Dakota. That highway runs east-west and passes through Groton. State Route 10 is described in Section 3.11.2.1 above. State Route 27 is a paved two-lane road oriented north-south in the eastern part of the study area. It connects to North Dakota Route 32 near Havana, North Dakota, and to U.S. Highway 12 east of Andover, South Dakota. State Route

37 is a two-lane paved road oriented north-south. It connects to U.S. Highway 12 at Groton and to North Dakota Route 1 north of Hecla, South Dakota. Many paved, gravel-surfaced, or dirt county and township roads form an incomplete grid in the area. (State of South Dakota, 1989)

Major roads of the North Dakota portion of the transmit-site powerline study area include State Routes 1, 11, and 32. State Route 1 is a two-lane paved road oriented north-south which connects to State Route 11 west of Ludden, North Dakota, and to South Dakota Route 1 near Hecla, South Dakota. State Route 11 is a two-lane paved road oriented east-west. It connects to State Route 32 at Forman, North Dakota, and to U.S. Highway 281 at Ellendale, North Dakota. State Route 32 is a two-lane paved road oriented north-south. It connects State Route 11 at Forman and to South Dakota Route 27 south of Havana, North Dakota. Numerous other county and township paved, gravel-surfaced, and dirt roads form an incomplete grid in the area. (State of North Dakota, 1989)

3.11.4.2 Receive Site

The major roads of the powerline study area for the receive site include State Highways 1 and 32 and Routes 36 and 68. State Highway 1 is a two-lane paved road which connects to State Highway 32 at Thief River Falls and to U.S. Highway 75 at Warren, Minnesota. State Highway 32 is a two-lane paved road oriented north-south. It connects to U.S. Highway 2 near Marcoux, Minnesota. Route 36 is a two-lane paved road that passes north-south through Radium, Minnesota and connects to State Highway 1 about 2 miles south of Radium. Route 68, the continuation of Route 36 south of the Marshall/Pennington county line, is described in section 3.11.3.2 above, (Minnesota Department of Transportation, 1985). Many other gravel and dirt roads form an incomplete grid in the study area.

3.12 CULTURAL RESOURCES

3.12.1 Overview

Cultural resources and cultural resource sites refer to prehistoric, Native American, and historic sites, districts, buildings, structures, objects, and any other physical evidence of past human activities. Of particular concern are historic properties and traditional, religious, and sacred sites. Historic properties are those cultural resources and cultural resource sites that are listed on, or eligible for listing on, the National Register of Historic Places (NRHP). (Federal Register, 1988) Traditional, religious, or sacred sites are locations that have traditionally been considered important to a Native American for religious or cultural reasons.

Several studies were undertaken to inventory cultural resources that may be affected by the CRS. A literature and records search of known resources was completed for the proposed transmit and receive site and powerline corridor study areas. A limited sample survey of the transmit CSAs was performed. Additional studies currently underway include consultation with local residents, artifact collectors, historical societies, and Native American groups and individuals who are known to have historical ties to the proposed study areas. The information generated in this research has been used to prepare a draft Cultural Resources Management Plan (CRMP) and a draft Programmatic Agreement (PA) that, when finalized, will govern the identification, evaluation, and treatment of cultural resource sites throughout the Environmental Impact Analysis Process (EIAP).

3.12.2 Cultural History of Northeastern Subarea of Great Plains

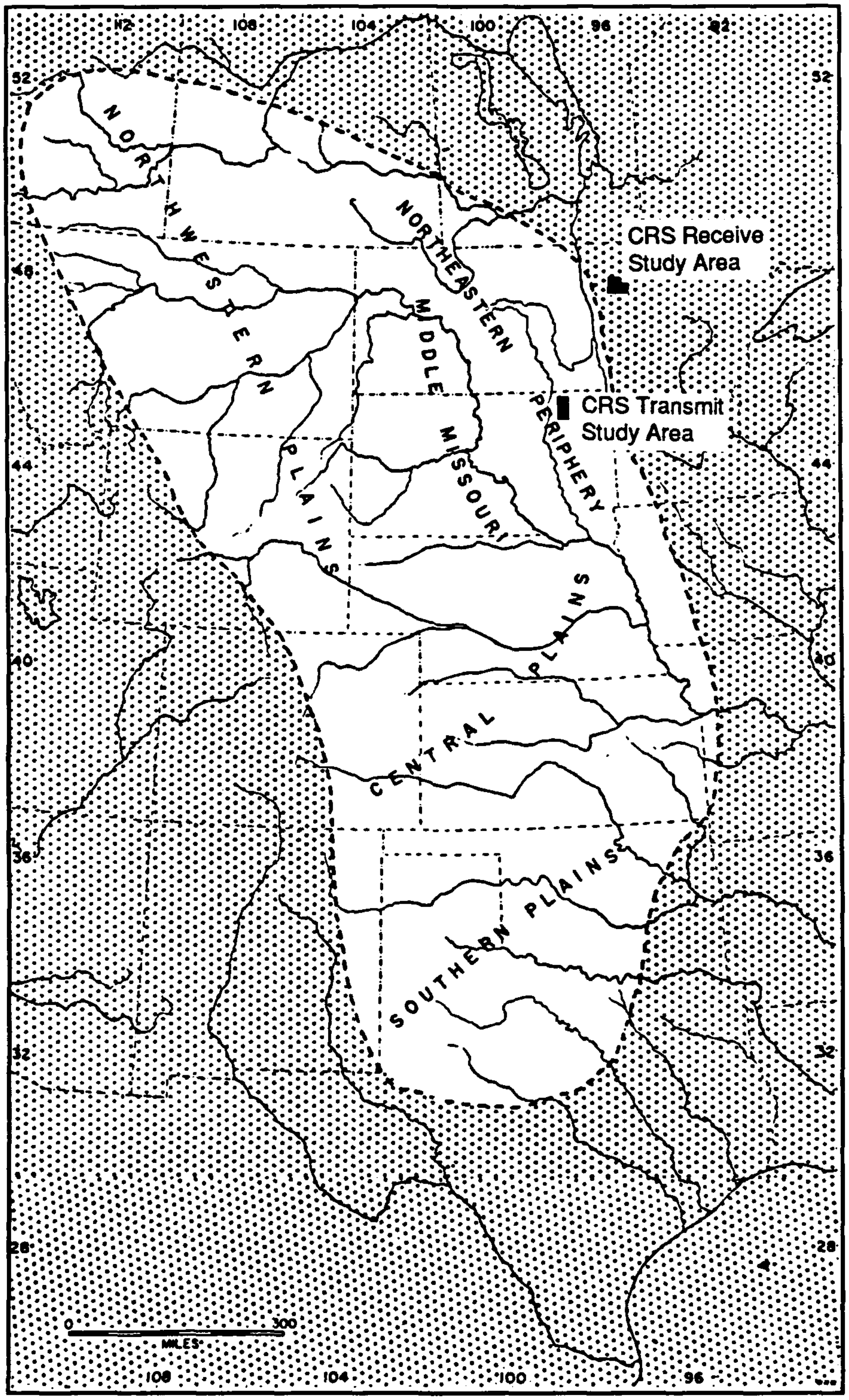
The CRS transmit study area and powerline corridors are located within the Northeastern Subarea of the Great Plains of North America, or the Northeastern Periphery. The CRS receive study area and powerline corridors are adjacent to the Northeastern Periphery. The Northeastern Plains, located to the north and east of the Missouri River Valley of the Dakotas (see

Figure 3.12.1), are in the eastern portion of the Missouri Plateau which is referred to as the glaciated Missouri section. (Fenneman, 1931; Flint, 1955; Hunt, 1967) Major streams flowing southward into the Missouri River include the James, Vermillion, and Big Sioux rivers. To the north of the Missouri Basin, the Red River drainage system flows northward into Lake Winnipeg, which eventually empties into Hudson Bay.

The terminal phases of Wisconsin glaciation are principally responsible for the gross physiography of the Northeastern Plains. The last major continental glaciers receded from most of the region by about 11,500 years ago. During the Wisconsin glaciation, however, the North and South Dakota study area was covered by the James Lobe of the Laurentide continental ice sheet, and the Minnesota study area was covered by the Red River Lobe. (Brophy and Bluemle 1983; Flint, 1955) Glacial Lake Dakota was present in the valleys created by the James and Red River lobes, as was Lake Agassiz. Today, these valleys are occupied by the James and the Red rivers (see Figure 3.12.2).

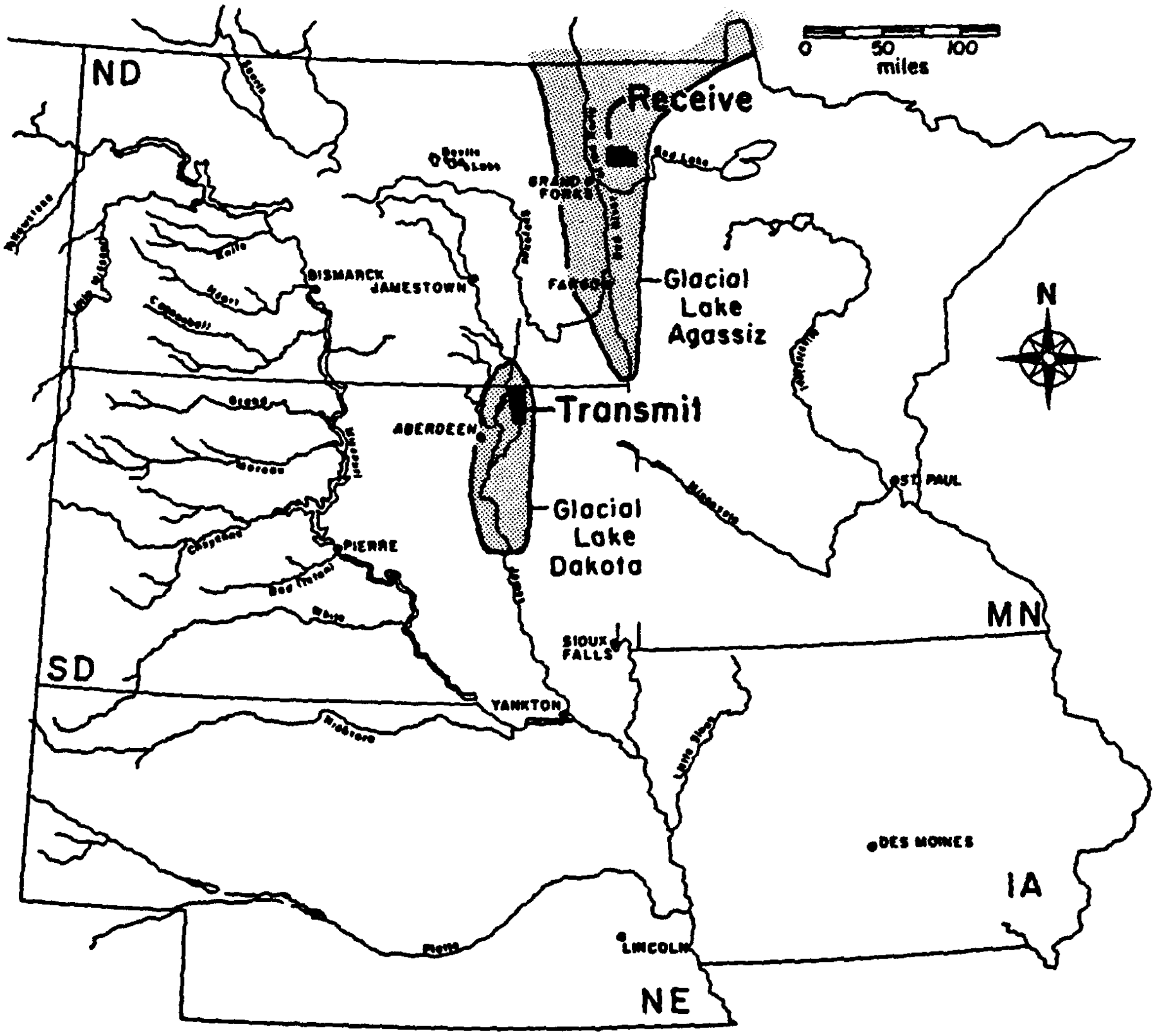
The Northeastern Plains subarea has been populated for about the past 11,000 years. A taxonomic model (see Figure 3.12.3) provides a temporal and cultural-historical frame of reference for recognized prehistoric and historic peoples who might have occupied the study region.

Cultural traditions denote and characterize the lifeways or general adaptive strategies of past populations. At a given time, more than one cultural tradition conceivably may have been represented in the study areas. Cultural periods are nonoverlapping segments of time, typically named for a cultural tradition that dominated a particular time frame. Cultural complexes refer to specific groups that exhibited distinctive material remains (e.g., a projectile point style, a pottery type, or some other set of material traits) that repeatedly occur, or can be expected to occur, at culturally-temporally related archeological sites.



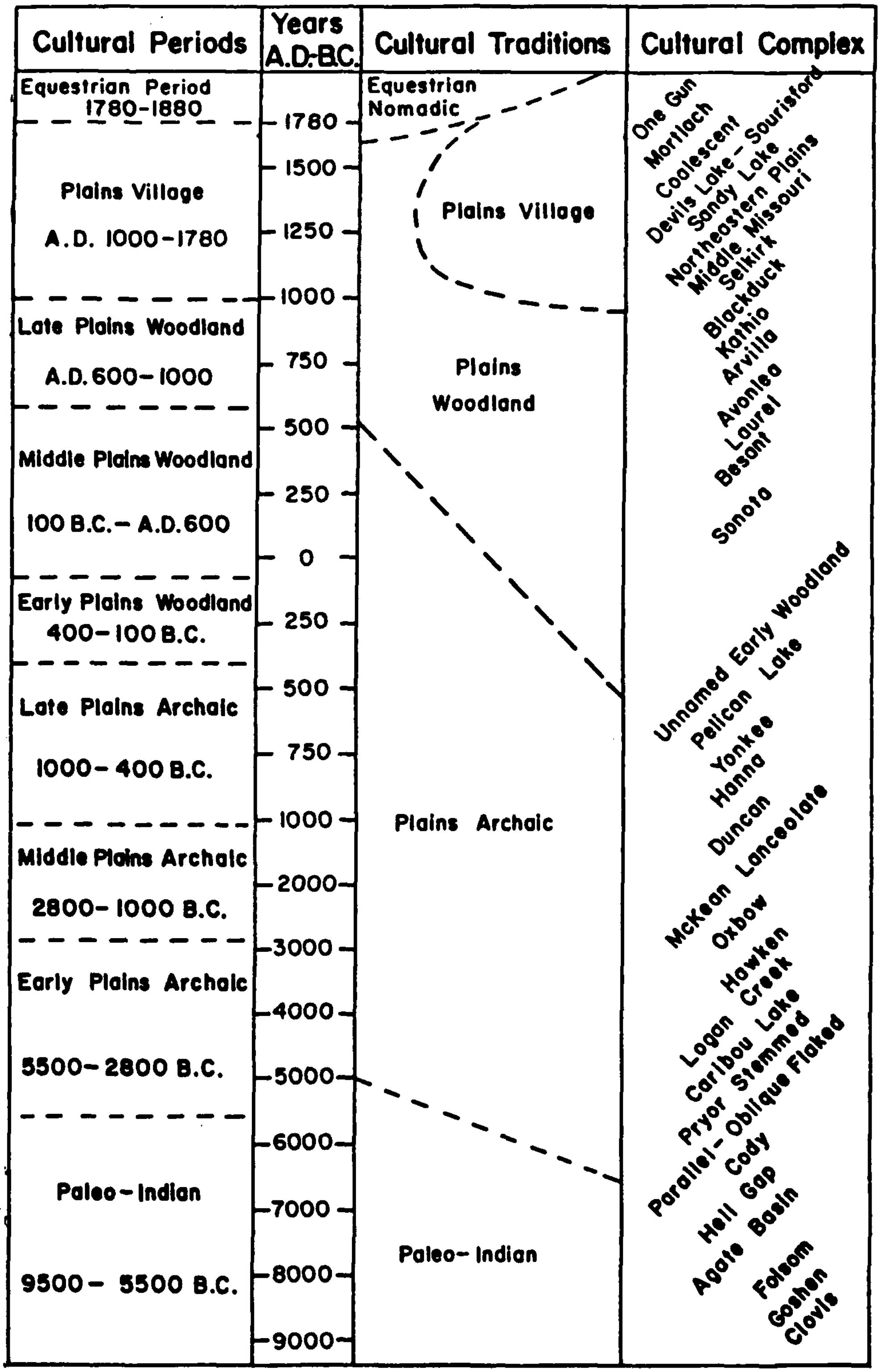
SOURCE: Wedel 1961

FIGURE 3.12.1 THE GREAT PLAINS CULTURAL AREA OF NORTH AMERICA AND ITS SUBAREAS



SOURCE: Gregg et al. 1986

FIGURE 3.12.2 CRS TRANSMIT AND RECEIVE STUDY AREAS IN RELATION TO GLACIAL LAKE DAKOTA AND GLACIAL LAKE AGASSIZ



SOURCE: *Adapted from Gregg et al. 1986*

FIGURE 3.12.3 GENERAL ARCHEOLOGICAL, TAXONOMIC, AND CHRONOLOGICAL MODEL OF THE NORTHEASTERN PLAINS

For the Northeastern Plains, six cultural traditions are identified. These include: 1) Paleo-Indian, 2) Plains Archaic, 3) Plains Woodland, 4) Plains Village, 5) Equestrian, and 6) Euro-American. (Buechler, 1984; Dobbs, 1989a and 1989b; Lehmer, 1971; Wedel, 1961; Willey, 1966) All six cultural traditions are potentially represented at the transmit study area and associated powerline corridors; all but the Plains Village tradition, which is not specifically recognized in northwestern Minnesota, potentially occur at the receive study area and associated powerline corridors.

The Paleo-Indian period covers a 4,000-year time span provisionally dated from ca. 9500 to 5500 B.C. This cultural period encompasses the time when the initial peopling of the glacial Lake Dakota plain (James River lowland) and the glacial Lake Agassiz plain (Red River Valley) occurred following the final recession of Wisconsinan ice sheets. These earliest hunting and gathering populations hunted mammoth, mastodon, and bison. In this sense, the Paleo-Indian tradition is also referred to as the Big Game Hunting tradition. (Willey, 1966)

The succeeding Plains Archaic tradition also had an economy based on hunting and gathering, but one that was adapted to Holocene (recent) plant and animal resources. The Archaic period, dated between 5500 and 400 B.C., has been divided into Early, Middle, and Late subperiods, based on distinctive styles of artifacts made from stone and sometimes native copper.

The lifeways of succeeding Plains Woodland tradition peoples are thought to have been similar to those of the Plains Archaic tradition in many ways. Both were essentially nomadic and both had subsistence economies based on hunting and gathering. Complex mortuary practices including elaborate mound burials, the routine production of ceramic (pottery) containers for cooking and storage, and use of the bow and arrow are three distinctive Woodland traits that clearly differentiate it from the preceding Archaic.

The Woodland lifeway began at ca. 400 B.C. and lasted until A.D. 1000 in some parts of the subarea, persisting into protohistoric times in areas along the prairie-woodland boundary.

The Early Woodland period is poorly known in the Northeastern subarea; its beginning is apparently marked by the inception of pottery manufacture. The use of the bow and arrow seems to have been well established by the beginning of Late Woodland times. The subsistence economy of Woodland peoples remained focused on hunting and gathering, but some gardening or at least experimentation with plant domestication was probably taking place during the Late Woodland peri...

The Plains Village tradition is characterized by a semisedentary settlement pattern and a mixed subsistence economy based on hunting, gathering, and simple garden agriculture. Permanent earthlodge villages, both fortified and unfortified, were built by Plains Village peoples and served as their residential bases. Such sites, some of which covered several hectares, were most commonly found to the west along the Missouri River in the Middle Missouri Subarea of the Plains. (Lehmer, 1971)

The Equestrian tradition spans the late protohistoric and early historic periods (ca. A.D. 1780-1860) following Euro-American contact and the introduction and adoption of horses and guns among the native peoples of the Plains. (Denig, 1961; Secoy, 1953) The widespread availability of guns and horses at this time, a direct by-product of the fur trade, gave rise to the mounted nomadic tribes of the Plains. Notable Equestrian tribes in the Northeastern Plains during early historic times included the Yankton and Yanktonai Dakotas (Sioux), the Cheyennes, and the Assiniboines. Although not known to possess horses, the Chippewas via their active participation in the regional fur trade can be loosely grouped with this cultural tradition as well.

The Euro-American tradition represents the dominant nonnative presence of the recent historic period. The earliest Euro-American presence in the Northeastern Plains was fur traders from about A.D. 1740 to 1850. (Swagerty, 1988; Wood and Thiessen, 1985) Fur trade brought about the establishment of trading posts along Lake Traverse on the present-day Minnesota/South Dakota border. Later, in 1864, the U.S. military erected Fort Wadsworth (later Fort Sisseton) in South Dakota as an infantry post. In the following years, settlement increased slowly in the

region until the U.S. government land surveys of the early 1870s were completed and the area was opened to homesteading. Minnesota was admitted to the Union in 1858, and South Dakota and North Dakota in 1889.

Two periods of rapid economic expansion occurred in the next several decades. The first coincided with the arrival of rail service in the 1880s, providing transportation, an increased demand for food crops, and in Minnesota a demand for lumber that encouraged the logging industry. A second boom occurred between 1900 and 1917 with the arrival of substantial numbers of European immigrants seeking homestead sites.

3.12.3 Transmit Study Area

The transmit study area is located within a broad, flat, low-lying region in northeastern South Dakota termed the James River Lowland. (Flint, 1955; Koch, 1975; Schultz, 1975) This setting comprises the former bed of glacial Lake Dakota. Terrain in the transmit study area can be characterized as flat to gently rolling. In parts of the study area, especially in the north, deposits of windblown sand account for the hummocky appearance of the local topography. (Flint, 1955) Poorly drained marshy areas and potholes dot the landscape in some low-lying spots surrounding the study area.

Most investigations of cultural resources have taken place to the west of the study area along the James River in South Dakota and North Dakota. The earliest professional archeological work was conducted by T. H. Lewis, who focused on recording mounds and other earthworks in the James Valley in the 1880s. (Lewis, n.d.) The archeological sites documented by these early investigations were mainly prominent ones such as Woodland mounds and Plains Village encampments.

During the late 1970s and into the 1980s, large-scale archeological inventory and testing projects were conducted along the James River in northeastern South Dakota and southeastern North Dakota. (e.g., Good et al., 1977; Gregg et al., 1985; Haberman, 1983a, and 1983b;

Hannus, 1982; Haug, 1983; Keller and Keller, 1982, and 1983; Kordecki and Gregg, 1986; Schneider, 1977; Vehik, 1976) The findings of these projects and the few other earlier investigations provide much of the basis for the existing scant prehistory for the area. Extensive architectural surveys have been completed in Brown County, South Dakota, covering portions of the various study areas for the transmit site. These include the Finnish Thematic Survey and the Brown County Geographical Survey, during which a number of significant and potentially significant architectural sites were recorded, consisting of a variety of rural and city (town) properties. (Torma, 1989) Marshall and Day counties in South Dakota, which also contain portions of the transmit and powerline study areas, have not been surveyed as extensively for architectural sites, so far fewer sites are recorded for these areas.

Search of the literature and records covering the transmit CSAs did not reveal any known and recorded cultural resource sites in either the northern CSA or the southern CSA, nor were any sites specifically identified within the transmit study area. Within about 3 mi of the transmit study area, however, 17 recorded sites are located (see Figure 3.12.4). These sites include one prehistoric/historic archeological site, two historic archeological sites, six rural architectural sites, and eight architectural sites in the City of Claremont (see Table 3.12.1). One of the rural architectural sites, the Augustana Swedish Lutheran Church, is listed on the NRHP. None of the other recorded sites is listed on the NRHP, but some are considered to be potentially eligible. To date, no Native American traditional or sacred sites have been identified in or near the CRS transmit study area through efforts to elicit information from regional tribal governments and certain individuals.

3.12.3.1 Northern CSA

No previous archeological surveys are known for the northern transmit CSA. Based on background research and the results of the sample survey, resource density is expected to be low. Recorded sites potentially impacted by the construction of the transmit antenna include two

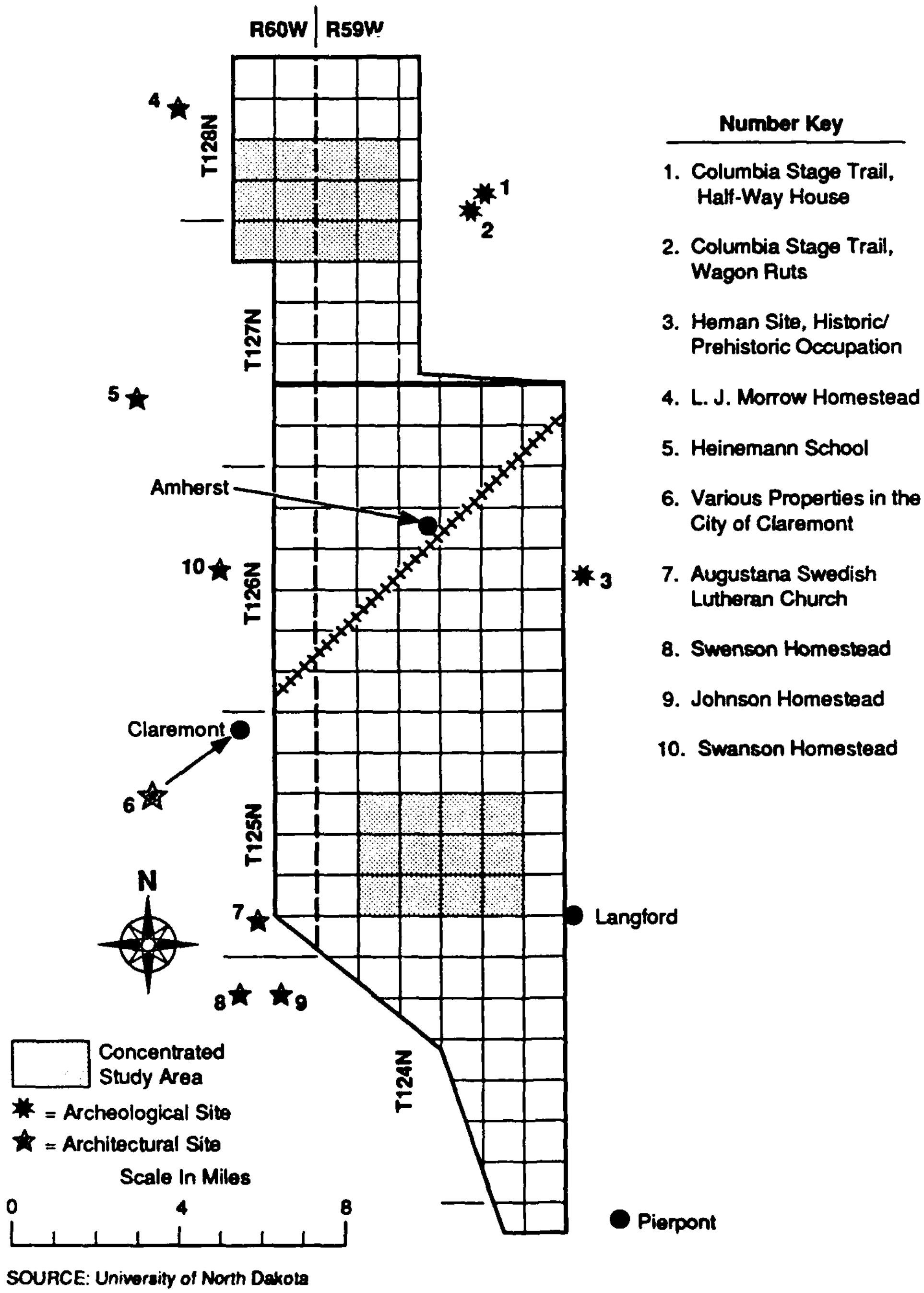


FIGURE 3.12.4 RECORDED CULTURAL RESOURCE SITES NEAR THE CRS TRANSMIT STUDY AREA, SOUTH DAKOTA

Table 3.12.1
RECORDED CULTURAL RESOURCE SITES NEAR THE CRS TRANSMIT STUDY AREA, SOUTH DAKOTA

Site Name and Number (if any)	Site Type and Description	National Register Status
Sites Closest to the Northern CSA		
Columbia Stage Trail, 39ML38	Historic archeological site: remains of a "half-way house" stage stop on the old Columbia Trail	Undetermined
Columbia Stage Trail, 39ML39	Historic archeological site: wagon ruts across virgin prairie marking the route of the Columbia Stage Trail, ca. late 1800s	Undetermined
L. J. Morrow Homestead, BN-PG-6	Historic architectural/agricultural site: several buildings in an occupied farmyard; barn may be of significance	Potentially eligible
Heinemann School, BN-ND-1	Historic architectural/educational site: good example of an early rural school, built in 1884	Potentially eligible
Sites Closest to the Southern CSA		
Heman Site, 39ML40	Historic/prehistoric archeological site: aboriginal occupation site known locally as an "Indian camp"	Undetermined
Swanson Homestead, BN-SD-1	Historic architectural/agricultural site: buildings in an occupied farmyard; house and barn may be of significance	Potentially eligible
City of Claremont	Eight historic architectural sites in the city of Claremont	
Claremont School, BN-CL-CL-1	Historic architectural/educational site: first classes held in 1913, school closed in 1969	Potentially eligible
Thorpe Grain Elevator, BN-CL-CL2	Historic architectural/agribusiness site: this 1896 structure exemplifies the important relationship between agriculture and the railroad	Potentially eligible

Table 3.12.1
(Concluded)

Site Name and Number (if any)	Site Type and Description	National Register Status
City of Claremont (continued)		
Hutch Store, BN-CL-CL-6	Historic architectural/commercial site: early small store typical to the area	Potentially eligible
C.A.Olson Home, BN-CL-CL-7	Historic architectural/residential site: well-maintained early 1890s residence	Potentially eligible
Blacksmith Shop, BN-CL-CL-10	Historic architectural/commercial site: example of a building used for an important community service	Potentially eligible
Dr. Densmore Office, BN-CL-CL-12	Historic architectural/commercial site: this 1899 structure was used to house an early medical practice	Potentially eligible
Methodist Church BN-CL-CL-13	Historic architectural/religious site: built from 1887-88, this structure is a fine example of an early rural church	Potentially eligible
Elevator House BN-CL-CL-14	Historic architectural/residential site: good example of an early residence	Potentially eligible
Augustana Swedish Lutheran Church	Historic architectural/religious site: good example of Swedish-American vernacular church architecture; Augustana cemetery is 1 mi to the southeast of the Church	Listed
Swenson Homestead, BN-RS-1	Historic architectural/agricultural site: buildings in an occupied farmyard; no mention of any particularly important structures	Potentially eligible
Johnson Homestead, BN-RS-3	Historic architectural/agricultural site: buildings in an occupied farmyard; the house, built in 1899, may have had the first indoor plumbing in Brown County	Potentially eligible

Source: University of North Dakota, 1990.

historic archeological sites associated with the Columbia Stage Trail. The remains of a half-way house stage stop and wagon ruts on the old Columbia Trail are located slightly more than 1 mi from the eastern boundary of the CSA. The NRHP eligibility of the sites is currently undetermined and would require formal evaluation.

A sample survey of 13.3% of the northern CSA resulted in the discovery and investigation of three historic archeological sites, two isolated artifact finds, three site leads, and one anomalous feature (see Table 3.12.2). None has been initially evaluated as NRHP-eligible sites.

Table 3.12.2
CULTURAL RESOURCE SITES AND POTENTIAL SITES AT THE NORTHERN TRANSMIT CSA

Site Number/ Name	Component Descriptive Type	Component Cultural Affiliation	Size (acres)
39BN109	Dump (recent)	Euro-American (recent)	0.62
39ML53	Dump(s)	Euro-American (recent)	7.41
39ML54	Landreth Farmstead (abandoned)	Euro-American (recent)	7.91
J6-13A	Isolated find: single chalcedony flake	Unknown prehistoric	0.02
J26-11A	Isolated find: single fire-cracked rock (?)	Unknown prehistoric	0.02
Stehly Site Lead	Indian occupation site (?)	Unknown prehistoric/ Historic	?
Tisher Site Leads	Indian occupation site (?)	Unknown prehistoric/ Historic	?
Donovan Cross	Simple memorial (?)	Euro-American (recent)	0.02

Source: University of North Dakota, 1990

Site 39BN109 is a small, unnamed historic dump site that consists of a sparse scattering of recent domestic debris found in the bottom of a large blowout depression. Site 39ML53 consists of a series of historic dump locations in rolling terrain containing many sand dunes and blowouts. Artifactual debris is typical of what one might expect from a local farm/ranch operation. The Landreth site (39ML54) consists of the remains of an abandoned farmstead or ranch that may have been a dairy operation. The site consists of structural remains including a corral and a wide variety of domestic and farm-related materials. The isolated artifact find designated J6-13A consists of a single piece of chipped stone flaking debris made of brown chalcedony. It was found on a deflated, hard-packed surface in a bare patch of ground currently used as a cattle feedlot.

Isolated Find J26-11A is a single spall of granitic rock found on a rodent backdirt pile situated in gently rolling and grass-covered terrain. The specimen appears to be genuine and is probably the by-product of the use of heated stones to cook food or for some other activity requiring the generation of steam-heat. (House and Smith, 1975) This isolated find is located directly to the west of a large blowout depression where, according to the current landowners, Indian artifacts have been found in the past when erosion was active. A thorough search of the blowout depression and surrounding area (Stehly Site Lead) failed to yield any other artifacts.

The Donovan Cross is a small, white inscribed wooden cross located by the side of a road. Additional inquiries are needed to determine precisely what this feature represents because it does not appear to mark the location of a grave.

The northern CSA is an area of local sandhills that were subject to active and substantial erosion and deposition and redeposition of sediments at various times throughout the Holocene, most recently during the drought years of the 1930s. Interviews with local persons and field observations indicate that the face of the northern CSA is very recent, formed by the blowing and shifting sands of the 1930s. Considerable evidence suggests that the landscapes of the past have

been largely destroyed by wind erosion, and what might remain of old landscapes probably lies buried beneath meters of sand in most places. Such circumstances make it improbable that prehistoric and even early historic archeological sites will be found in the northern transmit CSA by conventional surface surveys.

3.12.3.2 Southern CSA

No previous archeological surveys are known for the southern transmit CSA. Resource density is expected to be low based on background research and the limited sample survey conducted. Recorded sites include two historic architectural/agricultural sites that are both potentially eligible for inclusion on the NRHP. The Swenson Homestead, located approximately 3.5 mi southwest of the southwest sector, consists of buildings in an occupied farmyard. The Johnson Homestead, built in 1899, consists of buildings in an occupied farmyard; the house may have had the first indoor plumbing in Brown County. The homestead is located approximately 2 mi southwest of the Tx-S layout. Further evaluation of both homesteads is required with respect to their NRHP eligibility. The Augustana Swedish Lutheran Church is located slightly more than 2 mi to the west of the southwestern corner of the southern CSA. The NRHP eligibility of this listed property is based solely on its architectural merits and not related to its setting.

A sample survey of a little more than 6% of the southern CSA resulted in the discovery of one historic archeological site, two prehistoric archeological sites, and one isolated artifact find (see Table 3.12.3). The two prehistoric sites probably are not significant archeological resources, but will require formal testing and evaluation to determine their NRHP eligibility. The historic archeological site is not considered to be a significant cultural resource.

Table 3.12.3
CULTURAL RESOURCE SITES AND POTENTIAL SITES AT THE SOUTHERN TRANSMIT CSA

Site Number Name	Component Descriptive Type	Component Cultural Affiliation	Size (acres)
39ML55	Dump and Depression	Euro-American (Recent)	0.15
39ML56	Artifact Scatter	Unknown Prehistoric (PlainsArchaic/Woodland/Village?)	19.52
39ML57	Artifact Scatter	Unknown Prehistoric (Plains Village?)	6.42
L27-13A	Isolated Find: Single Trailed Pot Sherd	Unknown Prehistoric (Plains Village?)	0.02

Source: University of North Dakota, 1990

Site 39ML55 consists of an historic trash dump and an associated depression that may represent the remnants of a homestead (dugout-style structure) or a small farmstead. Site 39ML56 is a broad, diffuse surface scatter of prehistoric artifacts in a plowed field. Evidence suggests that 39ML56 is a multicomponent prehistoric occupation site. A plain, grit-tempered potsherd points to a Plains Village (late prehistoric) component. Site 39ML57 appears to be a single-component prehistoric occupation site. It consists of a sparse surface scatter of artifacts such as chipped stone tools, flaking debris, and fire-cracked rock. L27-13A consists of a solitary potsherd found in a plowed field near an unnamed ephemeral drainage. The specimen is reminiscent of the kind of pottery made and used by Plains Village groups in the James River Valley of present-day North Dakota. (Gregg et al., 1987; Swenson, 1987) No other artifacts were found with the ceramic sherd despite an intensive inspection of the surrounding area.

3.12.4 Receive Study Area

The CRS receive study area is situated in an interbeach area of the Agassiz Lake Plain district of the Central Lowlands physiographic province. (Fenneman, 1946; Hobbs and Goebel, 1982) At the close of the Pleistocene, Lake Agassiz covered much of northwestern Minnesota, including all of the receive study area (see Figure 3.12.2). Distinctive beach ridges were formed by the various levels of the lake as it receded. (Hobbs and Goebel, 1982; Kanivetsky, 1979) The Campbell beach ridge transects the the study area in the east; the Erskine Moraine lies to the east of the study area. (Hobbs and Goebel, 1982) The terrain in the receive study area is characteristic of a glacial lake bed setting. Relief is low, except where drainages have downcut and where beach ridges are present.

Very little previous archeological research has been undertaken in or near the receive study area. The few prior investigations have generally consisted of small-scale surveys conducted for small energy or recreational developments since the late 1970s. (e.g., Commonwealth, 1981; Harrison, 1984; Lane, 1977) Few archeological sites were recorded during these investigations. Identified properties in Polk and Pennington counties include Woodland habitation sites, Arvilla complex burial mound locations, Archaic Old Copper materials, and various prehistoric cultural material scatters of unspecified cultural affiliation. (Gregg and Picha, 1989b; Gregg et al., 1986; Johnson, 1973) Remains of historic features and facilities such as trails, sawmills, and early homesteads have been identified as well. (Gilman et al., 1979; Gregg and Picha, 1989b; Gregg et al., 1986; D. Hess, 1989; J. Hess, 1989)

Spot surveys of certain potentially significant architectural sites in Pennington County that are in or near the CRS receive study area were performed in 1972 and again in 1976 according to records at the Minnesota Historical Society (MHS). More recently, the Polk and Pennington county portions of the study area were included in the Historic Trails survey project sponsored by MHS. (D. Hess, 1989; J. Hess, 1989) There are no records of any historic architectural

surveys of those parts of Polk and Marshall counties in the vicinity of the CRS receive study area.

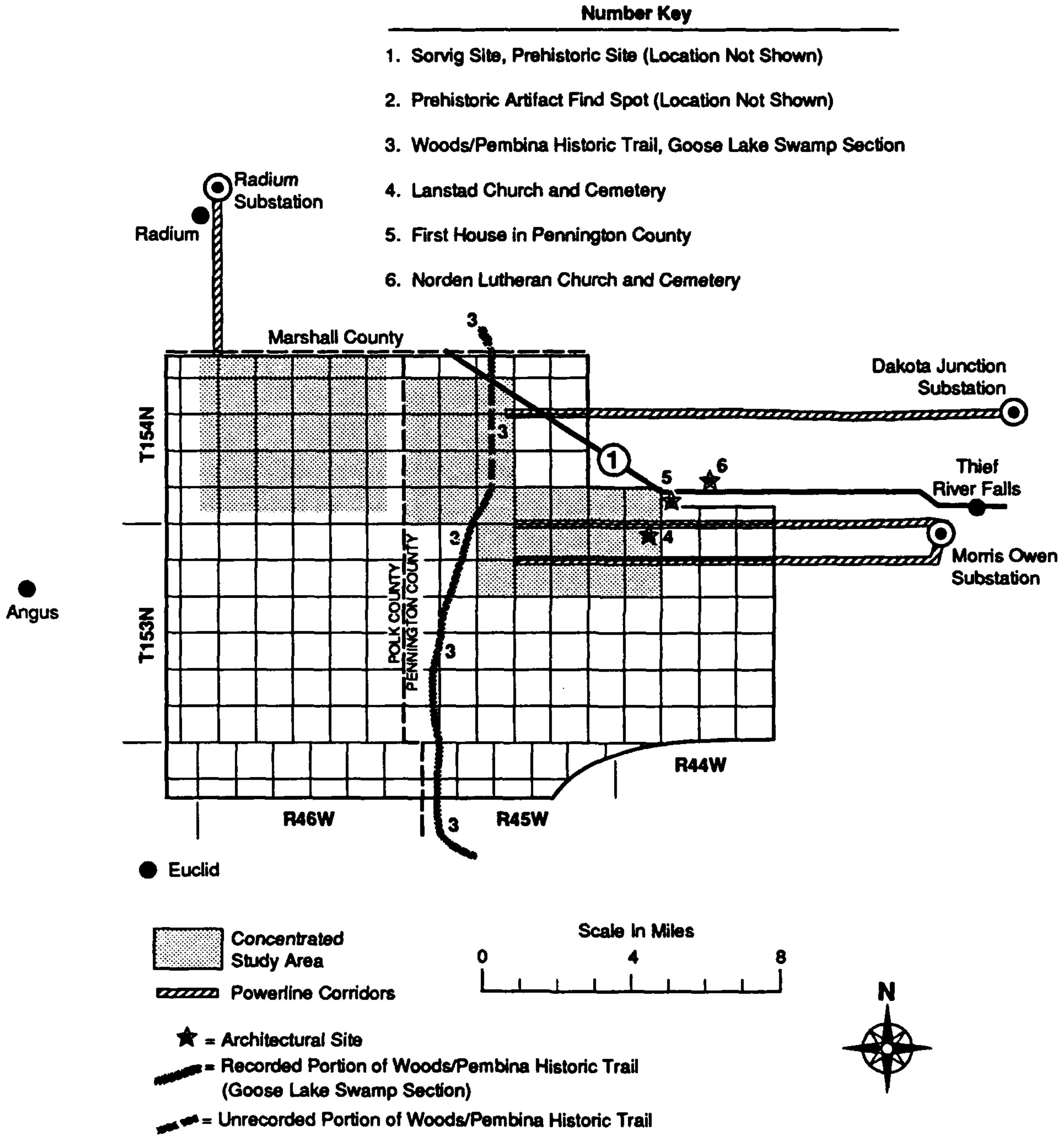
The literature and records search located two prehistoric archeological sites, a segment of the Woods/Pembina Trail and three historic architectural sites in or near the receive study area (see Table 3.12.4). The two archeological sites, 21PE1 and 21PE-FS01, are situated in the extreme southern portion of the receive study area. These were recorded in 1977 and have yielded artifacts of pottery, native copper, a chert "knife," and a grooved maul. The prehistoric find spot, which was recorded during the same interview with a local informant, yielded a single copper spearpoint. The Lanstad Church, built in 1882, is believed to be the first church in Pennington County. It is therefore an architectural and religious site of considerable local importance and potentially eligible for listing on the NRHP. The other two sites consist of the what is thought to be the first house and barn in Pennington County and the Norden Lutheran Church. These sites are also of local importance and potentially eligible for listing on the NRHP (see Figure 3.12.5).

The Goose Lake Swamp section of the Woods/Pembina Historic Trail traverses the center of the eastern CSA. A part of the historic Red River Trail system (ca. 1835-1871), it was used to move goods by oxcart for the Red River trade between St. Paul and Pembina from approximately 1844-1871. (D. Hess, 1989) The portion of the Woods/Pembina Trail that passes through the study area includes segments that may be eligible for listing on the NRHP, including a 2.5-mi segment of the Goose Lake Swamp Section located just to the south of the eastern CSA. (J. Hess, 1989) Another one mile segment of the Goose Lake Swamp section located just to the south of the study area is thought to be particularly well preserved and is in the process of being nominated to the NRHP. Other recorded portions of the Goose Lake Swamp section are less well preserved and may not retain sufficient integrity for listing on the NRHP (D. Hess 1989); however, its entire recorded 10-mi length has been recommended for preservation. (J. Hess, 1989)

Table 3.12.4
RECORDED CULTURAL RESOURCE SITES IN OR NEAR THE CRS RECEIVE STUDY AREA

Site Name and Number (if any)	Site Type and Description	National Register Status
Sorvig, 21PE1	Prehistoric archeological site: apparent occupation site with pottery, copper, and stone tools	Undetermined
21PE-FS01(9002)	Prehistoric find spot: copper "spear-point" found in plowed field; near 21PE1 and probably related	Undetermined
Woods/Pembina Trail; Goose Lake	Historic Red River Trails site: Goose Lake Swamp section of an oxcart trail used from ca. 1835-1871	Potentially eligible
Lanstad Church, Penn. County Sanders Twp. 1	Historic architectural/religious site: built in 1882, and thought to be the first church in Pennington County; isolated rural church with cemetery	Potentially eligible
First House in Pennington County, Penn. County Norden Twp. 1	Historic architectural/agricultural site: log house and barn thought to be the first in Pennington County	Potentially eligible
Norden Lutheran Church, Penn. County Norden Twp. 2	Historic architectural/religious site: isolated rural church with cemetery	Potentially eligible

Source: University of North Dakota, 1990



SOURCE: University of North Dakota

FIGURE 3.12.5 RECORDED CULTURAL RESOURCE SITES IN OR NEAR THE CRS RECEIVE STUDY AREA, MINNESOTA

To date, no Native American traditional or sacred sites have been identified in or near the eastern CSA, the western CSA, or the general receive study area through efforts to elicit information from regional tribal governments and certain individuals through the Minnesota Indian Affairs Council. A member of the Devils Lake Sioux Tribe in North Dakota indicated that a traditional or sacred site of interest may be located somewhere between Crookston and Thief River Falls, Minnesota.

3.12.4.1 Eastern CSA

No archeological surveys have been conducted in the eastern receive CSA. As discussed in the preceding section, a recorded portion of the historic Woods/Pembina trail and an unrecorded segment traverse the CSA and lie within 0.25 mi of the preliminary site layout (see Figure 3.12.5).

The eastern CSA contains a number of beach ridges left by the recession of glacial Lake Agassiz. Early hunting and gathering populations were attracted to the beach ridge areas of glacial Lake Agassiz, which were preferred for various reasons such as the ecological diversity or the ability to survey lower ground. Therefore, these beach ridge areas are thought to have a potential for containing significant archeological sites far beyond anything represented in the other three CSAs.

3.12.4.2 Western CSA

No archeological surveys have been conducted in the western receive CSA, and no recorded sites are known to exist in this CSA.

The western CSA is very similar to the southern transmit CSA in South Dakota because both occupy old glacial lake beds. The western CSA is essentially flat and featureless with minimal wetlands area and is heavily cultivated. Archeological sites similar to those found in the southern transmit CSA in South Dakota would also be expected in the western CSA.

3.12.5 Power Supply

3.12.5.1 Transmit Site

The study area for the CRS transmit-site powerline corridors covers an extensive area of northeastern South Dakota and an adjoining portion of southeastern North Dakota. The entire southern area within South Dakota is mapped as part of the James River Lowland (Links 1-7). The northern links are in the drainage basin of the northward flowing Red River of the North (Hudson Bay drainage) (Links 7-10). Sand dune features associated with glacial Lake Dakota extend from northern South Dakota (Links 5 and 7) northward into Sargent County, North Dakota. (Bluemle, 1979; Larsen et al., 1964) Small streams flow through the region, including Mud Creek (Links 1 and 2), Crooked Creek (Link 9), Antelope Creek (Link 2), Johnson Slough (Link 9), and Crow Creek (Link 4). A number of constructed drainage systems cut across the study region, including the Dayton-Stena Ditch (Links 5, 6, and 8); the Crow Creek Ditch (Links 1 and 3); Ditch No. 11 (Link 7), and the Dayton-Crow Creek Ditch (Link 6). Unnamed ephemeral and permanent streams, lakes, and ponds occur in all links, but are more numerous in Links 2, 4, and 9.

The literature and records search revealed a variety of recorded archeological and architectural sites in the CRS transmit site power-supply study area. Only those sites that fall within one of the alternative corridors or within 1 mi of a corridor boundary are considered herein due to the narrow linear configuration of powerline ROWs. The information presented on recorded historic architectural sites is limited to sites actually listed on the NRHP, sites formally determined to be eligible for listing on the NRHP, and sites thought to be potentially eligible for listing on the NRHP.

The locations of 91 recorded cultural resource sites of importance or potential importance are located in or near these links (see Table 3.12.5). General site locations relative to the ten links are illustrated in Figure 3.12.6. Most of the recorded sites are historic architectural sites located

Table 3.12.5

RECORDED CULTURAL RESOURCE SITES IN OR NEAR THE CRS TRANSMIT-SITE POWERLINE CORRIDORS, NORTH AND SOUTH DAKOTA

Site Name and Number	Link	Site Type and Description	National Register Status
North Dakota sites			
City of Forman	10	Three historic architectural and/or archeological sites in the city of Forman	
Sargent County Courthouse, 32SA4		Historic architectural and local government site: county courthouse	Listed
Forman Post Office and Townsite, 32SAX17		Historic architectural/archeological site leads: old townsite and post office of Forman; could represent several individual properties	Undetermined
Forman Church 32SA325		Historic architectural/religious site: church with unspecified name/denomination	Potentially eligible
Dunbar (Sargent) Post Office, 32SAX18	9	Historic architectural/archeological site lead: old rural post office site; location similar to that for 32SAX19 below; may be one in the same	Undetermined
Blackstone (Sargent) Post Office, 32SAX19	9	Historic architectural/archeological site lead: old rural post office site; location similar to that for 32SAX18 above; may be one in the same	Undetermined
Belle Plaine Loading Station, 32SAX20	8	Historic architectural/archeological site lead: railroad facilities along an abandoned line of the former Great Northern Railway.	Potentially eligible
Brookland Post Office and Great Northern Railway Station, 32SAX21	8	Historic architectural/archeological potentially site lead: old rural post office and railroad facilities along an abandoned line of the former Great Northern Railway	Potentially eligible

Table 3.12.5
(continued)

Site Name and Number	Link	Site Type and Description	National Register Status
North Dakota sites (cont)			
Blackstone Post Office, 32SAX24	8	Historic architectural/archeological site lead: old rural post office site	Undetermined
Unnamed, 32SAX22	7	Prehistoric/historic archeological site lead: some sort of occupation site; no other specifics available	Undetermined
Nicholson Townsite, 32SA100	7	Historic architectural/archeological site: abandoned townsite and farmstead; some standing structures	Potentially eligible
Nicholson Cemetery, 32SA5	7	Historic archeological site(?): 23 graves dating from 1888-1976; may meet definitive criteria for an archeological site	Undetermined
Tewaukon Post Office	7	Historic architectural/archeological site lead: old rural post office site	Undetermined
Unnamed and Unnumbered Site	7	Prehistoric/historic archeological site lead: occupation site of some sort and associated effigy pipe findspot; no other specifics available	Undetermined
City of Havana	9	Two historic architectural sites in Havana	
Trinity Lutheran Church, 32SA322		Historic architectural/religious site: town church, significance unspecified	Potentially eligible
Havana Church, 32SA323		Historic architectural/religious site: town church, name/denomination and significance unspecified	Potentially eligible
South Dakota sites			
Columbia Stage Trail, 39ML38	3, 5	Historic archeological site: remains of a "half-way house" stage stop on the old Columbia Trail	Undetermined

Table 3.12.5
(continued)

Site Name and Number (if any)	Link	Site Type and Description	National Register Status
South Dakota sites (cont)			
Columbia Stage Trail, 39ML39	3, 5	Historic archeological site: wagon ruts across virgin prairie marking the route of the Columbia Stage Trail, ca. late 1800s	Undetermined
City of Claremont	1	Eight historic architectural sites in the City of Claremont:	
Claremont School, BN-CL-CL-1		Historic architectural/educational site: first classes held in 1913, school closed in 1969	Potentially eligible
Thorpe Grain Elevator, BN-CL-CL2		Historic architectural/agribusiness site: this 1896 structure exemplifies the *important relationship* between agriculture and the railroad	Potentially eligible
Hutch Store, BN-CL-CL-6		Historic architectural/commercial site: early kind of small store typical to the area	Potentially eligible
C. A. Olson Home, BN-CL-CL-7		Historic architectural/residential site: well-maintained early 1890s residence	Potentially eligible
Blacksmith Shop, BN-CL-CL-10		Historic architectural/commercial site: example of a building used for an important community service	Potentially eligible
Dr. Densmore Office, BN-CL-CL-12		Historic architectural/commercial site: this 1899 structure was used to house an early medical practice	Potentially eligible
Methodist Church BN-CL-CL-13		Historic architectural/religious site: built from 1887-88, this structure is a fine example of an early rural church	Potentially eligible
Elevator House BN-CL-CL-14		Historic architectural/residential site: good example of an early residence	Potentially eligible

Table 3.12.5
(continued)

Site Name and Number (if any)	Link	Site Type and Description	National Register Status
South Dakota sites (cont)			
Walters Farm, BN-GR-3	1	Historic architectural/agricultural site: several buildings in a currently unoccupied farmyard	Potentially eligible
City of Groton	1	65 historic architectural sites in two potential historic districts and as three individual sites; two sites listed on the National Register	
Downtown Historic District, BN-GR-GR-1-25		25 historic architectural/commercial sites relating to local commerce: banks, various offices, and office buildings, various stores, a bakery, a barber shop, restaurants/cafes, saloons/bars/lounge, a newspaper, a car dealership, an auto garage, grain elevators, and lumber yards	Potentially eligible
Residential Historic District, BN-GR-GR-26-62		37 historic architectural/residential sites relating to local homelife and religion; two sites in the district listed on the National Register, McKenzie-Cassels House and Trinity Episcopal Church	Potentially eligible
McKenzie-Cassels House BN-GR-GR-26		Historic architectural/residential site: local example of late Queen Anne architecture dating to 1898	Listed
Trinity Episcopal Church, BN-GR-GR-40		Historic architectural/religious site: unique type of rural church in South dating to 1883; owned by the Brown County Dakota Museum and Historic Society	Listed
Bowers and Irwin Building, BN-GR-GR-64		Historic architectural/commercial site: structure dates to ca. 1883 and possibly earlier and is among the first in Groton	Potentially eligible

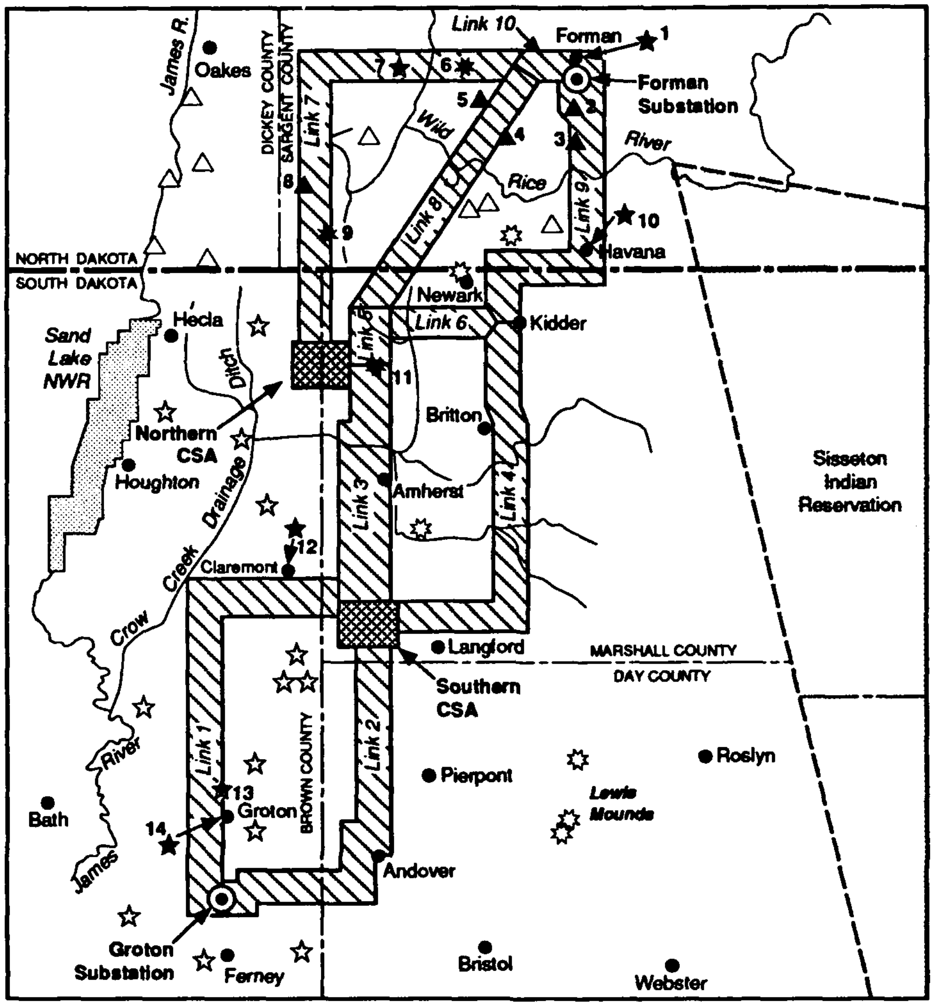
Table 3.12.5
(concluded)

Site Name and Number	Link	Site Type and Description	National Register Status
South Dakota sites (cont)			
City of Groton (cont.)	1		
First Presbyterian Church, BN-GR-GR-65		Historic architectural/religious site: the second site of the Presbyterian church in Groton; building began in 1911 with dedication in 1912	Potentially eligible
Gearys Gas Station, BN-GR-GR-66		Historic architectural/commercial site: early type of gasoline station dating to ca. 1931	Potentially eligible

Source: University of North Dakota, 1990

in the cities of Havana, Forman, Claremont, and especially Groton. The unusually large number of sites in Groton reflects the recording of many individual properties within two potential historic districts. Collectively speaking, the districts are considered to be potentially eligible for listing on the NRHP; however, the various properties that make up the districts are not necessarily eligible when evaluated solely on their own merits.

Only one rural historic architectural site is recorded in the South Dakota CRS transmit-site powerline corridors: the Walters Farm (BN-GR-3) (Link 1), in Brown County. The North Dakota powerline corridors contain several site leads that relate to possible but unconfirmed site locations that could be either historic architectural or archeological sites. Most of these historic architectural/ archeological site leads represent the locations of old rural post offices and railroad facilities identified by background research conducted in the 1970s as a part of the Regional Environmental Assessment Program (REAP) of North Dakota. (Tweton,1978)



N

Scale In Miles
0 5 10

◉ = Substations

= Corridors for Study

= Alternate Concentrated Study Areas for CRS Transmit Sites

= Archeological Sites and Site Leads

☆ ★ = Architectural Sites

△ ▲ = Various Recorded Historic Sites of Potential Importance (North Dakota)

Note:
Dark symbols represent cultural resources in or within 1 mile of links.
Open symbols represent cultural resources more than 1 mile from links.

SOURCE: University of North Dakota

Number Key

1. Various Properties in the City of Forman
2. Dunbar/Blackstone (Sargent) Post Office
3. Belle Plain Loading Station
4. Brookland Post Office and Great Northern Railway Station
5. Blackstone Post Office
6. Unnamed Prehistoric/Historic Archeological Site (32SAX22)
7. Nicholson Townsite and Cemetery
8. Tewaukon Post Office
9. Unnamed and Unnumbered Prehistoric/Historic Archeological Site
10. Various Properties in the City of Havana
11. Columbia Stage Trail Wagon Ruts and Waystation
12. Various Properties in the City of Claremont
13. Walters Farm
14. Various Properties in the City of Groton

FIGURE 3.12.6 RECORDED CULTURAL RESOURCE SITES IN OR NEAR THE CRS TRANSMIT POWERLINE CORRIDORS (LINKS), NORTH DAKOTA AND SOUTH DAKOTA

The historic Nicholson Townsite (32SA100) (Link 7), in North Dakota is potentially eligible for the NRHP. (Schweigert and Jessen, 1983) The Nicholson Townsite contains both architectural and archeological features consisting of standing structures and structural remains such as foundations and cellar depressions. Because the Nicholson Townsite is abandoned, it is probably best treated as a historic archeological site. The Nicholson Cemetery, recorded as site 32SA5, is located about 0.5 mi southeast of the old town site. The NRHP status of the Nicholson Cemetery has not been determined.

Two historic archeological sites are recorded in the South Dakota powerline corridors. Both sites relate to the old Columbia Stage Trail that was in operation in this area during the late 1800s. The first site, 39ML38, contains the remains of what is described as a half-way house stage stop. The second site, 39ML39, located directly southwest of 39ML38, consists of a well-preserved section of the Columbia Stage Trail that is just a little over 0.5 mi long and is marked by wagon ruts crossing virgin prairie. Although the status of these sites with respect to the NRHP is currently undetermined, they are of local significance and therefore potentially eligible.

Only two recorded prehistoric or early historic archeological sites are situated in or near the CRS transmit powerline corridors. Both are in North Dakota, and both are of Native American affiliation. Site 32SAX22 and the other site, which is unnamed and unnumbered, apparently represent an occupation site.

To date, no Native American traditional or sacred sites have been identified in or near the transmit powerline corridors through efforts to elicit information from regional tribal governments and certain individuals. Additional Native American contacts and initial local contacts regarding important cultural resources will be made to develop these sources of information.

Link 1: Link 1 is located in South Dakota and contains the cities of Claremont and Groton in or along its borders. Crow Creek Drainage Ditch cuts through the link. Areas of higher

cultural resource potential are located along Mud Creek and ephemeral streams, lakes, ponds, and a flowing well.

A total of 74 historic architectural sites are located in Link 1. The City of Claremont contains eight historic architectural sites, all of which are potentially eligible for inclusion in the NRHP. The City of Groton contains 65 historic architectural sites: 25 historic architectural/commercial sites are contained in the Downtown Historic District, and 37 historic architectural sites are located in the Residential Historic District. All are potentially eligible for inclusion in the NRHP. The district, in total, is also potentially eligible for inclusion on the NRHP, relating to local homelife and religion. Three individual historic architectural sites are also located within the City of Groton.

Link 2: Link 2 is located in South Dakota and contains the City of Andover in the south. Numerous intermittent lakes and streams occur in the link, including Mud and Antelope creeks. No recorded historic architectural sites are currently known in Link 2.

Link 3: Link 3 is located in South Dakota. The City of Amherst is located immediately outside its eastern border. Two historic archeological sites associated with the Columbia Trail are located on the northern portion of the link along the border of Link 5. Further evaluation of the sites is required to determine their NRHP eligibility. No recorded historic structures are currently known within Link 3.

Link 4: Link 4 of the powerline corridor is located in South Dakota. Areas of higher resource potential are numerous for Link 4 and are located near Hickman Lake, along Crow Creek, and other intermittent and permanent streams, lakes, and ponds. No recorded historic structures are known within Link 4.

Link 5: Two historic archeological sites associated with the old Columbia Trail are located in the southern portion of Link 5. These are the same sites described for Link 3; further

evaluation is required to determine their NRHP eligibility. No recorded historic structures are currently known within Link 5.

Link 6: Link 6 is located in South Dakota. The City of Newark is situated more than 1 mi to the north of the link. The Dayton-Stena and Dayton-Crow ditches cut across Link 6 in a north-south direction. Currently, no recorded historic structures are known within Link 6.

Link 7: Areas of higher cultural resource potential within Link 7 are located along the Wild Rice River, the marshy areas associated with Pickell Slough and Lake Taayer, several flowing wells, and intermittent streams and ponds.

Two recorded prehistoric/historic archeological sites and one possible historic archeological sites are located within Link 7. Further evaluation must be carried out to determine their NRHP eligibility. Two recorded historic architectural sites are also located within Link 7. The Nicholson Townsite is potentially eligible for inclusion on the NRHP. The Tewaukon Post Office requires further evaluation to determine its NRHP eligibility.

Link 8: Areas of higher cultural resource potential within Link 8 are located along the Wild Rice River, ephemeral streams, and a small marshy area in the northern portion of the link. Three rural historic architectural/archeological site leads are recorded within Link 8. The Brookland Post Office and the Great Northern Railway Station are listed as potentially eligible for inclusion in the NRHP. The status of the Blackstone Post Office is undetermined, and the Belle Plaine Loading Station is potentially eligible for listing. Further evaluation is required to determine their NRHP eligibility.

Link 9: The highest potential for prehistoric archeological sites in this corridor is along Crooked Creek, Johnson Slough, the Wild Rice River, and numerous intermittent and permanent streams, ponds, lakes, and marshlands. A total of four historic sites are recorded in or near Link 9. Two rural historic architectural/ archeological sites leads consisting of the Dunbar (Sargent) Post Office and Blackstone (Sargent) Post Office, are located in the northern portion of Link 9.

Further evaluation is required to determine their NRHP eligibility. The City of Havana contains two historic architectural sites. Both are potentially eligible for inclusion on the NRHP, pending further evaluation.

Link 10: The City of Forman contains three historic architectural and/or archeological sites. The Sargent County Courthouse is listed on the NRHP. The Forman Post Office and Townsite and Forman Church require further evaluation to determine their NRHP eligibility.

3.12.5.2 Receive Site

The powerline corridors for the CRS receive site are located in an interbeach area of the glacial Lake Agassiz plain. (Hobbs and Goebel, 1982) The Radium Substation corridor crosses branches of the Snake River and the South Branch of the Snake River along with another unnamed ephemeral drainage. Both alternative corridors connecting to the Morris Owen Substation and the Dakota Junction Substation corridor cross several glacial lake beach line features. Resource density is expected to be high for all four corridors.

The six recorded cultural resource sites previously discussed in Section 3.12.3 for the CRS receive study area are also located in or near the eastern powerline corridors that run west from the Morris Owen and Dakota Junction substations to Rx-E (see Table 3.12.4). The locations of the cultural resource sites relative to the eastern powerline corridors are illustrated in Figure 3.12.5.

To date, no Native American Indian traditional or sacred sites have been identified in or near the receive sector powerline corridors through efforts to elicit information from regional tribal governments certain individuals, and the Minnesota Indian Affairs Council in Bemidji.

Morris Owen Substation—The northern powerline corridor connecting to the Morris Owen substation is within 0.25 mi of the Lanstad Church and Cemetery, less than 1 mi from the first house in Pennington County, and about 1 mi south of the Norden Lutheran Church and

Cemetery. As noted, all sites are potentially eligible for listing on the NRHP, although the first house in Pennington County is described in the historic site files as being in very poor condition. The portion of the Woods/Pembina Historic Trail within the eastern receive CSA also crosses the likely route of the Morris Owen powerlines.

The southern CRS powerline corridor associated with the Morris-Owen Substation contains no recorded cultural resource sites within its boundaries. It is within 1 mi of the Lanstad Church and Cemetery, less than 2 mi from the first house in Pennington County, and approximately 2 mi from the Norden Church.

Dakota Junction Substation — No recorded historic or prehistoric properties other than the Woods/Pembina Historic Trail exist along the Dakota Junction powerline corridor. This corridor transects at least five glacial Lake Agassiz beaches or strandlines as well as the Thief River. Potential for the presence of prehistoric sites is high in all six of these areas.

Radium Substation — No historic or prehistoric sites are recorded near to the Radium Substation powerline corridor. The corridor, however, follows a section line next to the town of Radium and crosses a segment of Soo Line railroad track, the Snake River, and the South Branch of the Snake River. Buildings or other historic features associated with the town of Radium could be affected by this powerline. The Immanuel Church is adjacent to the corridor about 1 mi south of Radium.

The Snake River in this area is a permanent stream; the South Branch of the Snake River is an intermittent stream. The potential for prehistoric archeological sites along those streams is high.

4. ENVIRONMENTAL CONSEQUENCES

Section 4 discusses the environmental impacts that could result from construction and operation of the Over-the-Horizon Backscatter (OTH-B) Central Radar System (CRS) and powerlines at the alternative transmit and receive site layouts. In addition, it identifies measures that could be implemented to mitigate possible adverse effects on the environment.

4.1 GEOLOGY AND SOILS

4.1.1 Transmit Site

4.1.1.1 Tx-N

Construction of CRS transmit facilities at Tx-N would require site preparation to remove vegetation and deleterious surface materials; to create suitable slope gradients for drainage of storm runoff; to elevate low-lying areas and prevent ponding of runoff; to build elevated pads for the roads, groundscreens, antennas, and equipment buildings; and to lay gravel mats as surfaces for roads, parking areas, and groundscreens. The area affected by site preparation would be about 14 acres for construction of the access road, about 70 acres for construction of the perimeter roads, and about 427 acres for construction of the CRS transmit and sounder antennas and related facilities. Thus, the total area subject to vegetation removal and soil disturbance would be about 511 acres.

The access road would have two 10-ft-wide travel lanes and 4-ft-wide shoulders with a 6-in deep gravel surface to allow drainage. The road would be elevated 2-4 ft above the existing ground surface. The road length would be about 2 mi and about 45,000 cubic yards (yd^3) of fill would be required. The perimeter road would have a 10-ft-wide road surface with 4-ft-wide shoulders. The road would be a dirt road raised 2-4 feet above the existing ground surface. An estimated 225,000 yd^3 of fill would be required to construct the perimeter road and fence.

The groundscreen and transmit and sounder antennas at Tx-N would also be constructed on elevated earthen pads with a nearly level surface. Grading to remove unevenness of the ground surface and filling to construct the elevated pad would be necessary. In addition, a total of 25,000 ft^2 of gravel-surfaced parking areas, spread among the four sectors, would be built. The total volume of fill needed for those facilities is estimated at 593,000 yd^3.

In total, roughly 511 acres at Tx-N would be stripped of vegetation, graded, and covered with fill. The total fill volume would be about 863,000 yd^3. Grading and filling, however, would occur in two stages. In 1991, site preparation for the southeast and southwest CRS sectors would occur; site preparation for the east and west sectors would not occur until 1993 or 1994. Thus, about 262.5 acres would be graded and 454,000 yd^3 of fill would be emplaced in 1991. In 1993 or 1994, the east and west sectors of CRS would be started, requiring grading of 248.5 acres and emplacement of 409,000 yd^3 of fill.

One of the initial steps in site preparation would be to remove vegetative cover and deleterious soil. Stripping of vegetation would expose soil to rainsplash, overland flow, gully, and wind erosion, which occurs at a far higher rate on exposed than on vegetated soils. For the most part, the exposed soils of this site would be fine sandy loams highly susceptible to wind erosion. The soils have formed from wind-transported fine sediment that blankets the site. In areas of the site where the vegetative cover has been removed in the past, blowouts and dunes have formed. A similar scenario could result from CRS site preparation. Site soil would be less susceptible to water erosion than wind erosion, but formation of gullies and rills would be likely. Measures that would limit soil erosion are presented in Section 4.1.4—Mitigation Measures.

After the first summer of construction for the southeast and southwest sectors at Tx-N, the exposed soil would be covered by a packed gravel surface or man-made structures. Other areas would be expected to revegetate with grasses and low shrubs. Covering of the soil would substantially decrease erosion potential. During successive years, site vegetation would become more established, further reducing the potential for erosion. Thus, the most severe erosion impacts

would occur during the 1991 construction season for the initial two CRS sectors and during the 1993 or 1994 construction season for the final two sectors. During those years, wind erosion at the CRS site would be a significant impact. (See Section 4.3—Air Quality—for a quantitative estimate of dust generation.)

The northern transmit site has a maximum elevation difference of 65 ft and slope gradients are less than 5%. Site preparation would level the site and fill in depressions, but the depth of filling and cutting would be several feet at most. Because the site is currently nearly level, no significant topographic alterations would be necessary.

The soils at Tx-N have low potential for shrink-swell behavior and would present few limitations to road construction. The most important limitation would be poor drainage that would be mitigated by creation of positive slope gradients. Site soils should be suitable for use as fill; however, some fill would probably be required from off-site areas. The Air Force would prefer to acquire fill from an existing commercial borrow pit. No known commercial pits in the immediate vicinity could supply that fill; however, the Coteau des Prairies, about 16 mi east of the sites, contains abundant amounts of sand and gravel. If existing commercial quarries are unable to supply project needs, the system contractor would develop an off-site borrow source. Environmental guidelines for selection of an off-site borrow source are presented in section 4.1.4—Mitigation Measures.

Fill would be transported to the site by haul trucks with a capacity of about 20 yd^3 each. Up to 496 one-way trips per day would be required during site preparation for the initial two sectors. The trucks could drag or spill dirt onto local roads, inconveniencing other motorists.

No commercial sand and gravel mines are at or near the site. The project would not affect access to mineral resources.

4.1.1.2 Tx-S

During construction of the CRS at Tx-S, vegetation would be stripped, exposing bare soil to wind and water erosion as described above for Tx-N. The area affected by site preparation would

be 7 acres for construction of the access road, 70 acres for construction of the perimeter road and fence, and 427 acres for construction of the transmit and sounder antennas and related facilities. The total area subject to vegetation removal and soil disturbance would be about 504 acres.

Physical characteristics of the access and perimeter roads at Tx-S would be as described for Tx-N above. The access road would be 1 mi long, and the perimeter road would be 16 mi long. About 248,000 yd^3 of fill would be required for installation of the access road, perimeter roads, and security fencing. Construction of the groundscreen, transmit antennas, equipment buildings, sounder antennas, parking areas, and related structures would use about 1,188,000 yd^3 of fill.

In total, about 504 acres would be stripped of vegetation and about 1,435,500 yd^3 of fill would be emplaced. Site preparation would occur in two stages. Construction of the southeast and southwest sectors would begin in 1991, resulting in grading of 255.5 acres and emplacement of 729,000 yd^3 of fill. Construction of the east and west sectors would begin in 1993 or 1994, resulting in grading of 248.5 acres and emplacement of 706,500 yd^3 of fill.

Soils at Tx-S are generally siltier and more clayey than those at the northern site. Because of their fine particle size, these soils are somewhat more cohesive and therefore less susceptible to wind erosion than the Tx-N soils; however, a substantial potential for wind erosion of exposed soils would still exist. (See Section 4.3—Air Quality—for a quantitative estimate of dust production.) Bearden silt loam, Beotia-Bearden silt loams, Embden fine sandy loams, Great Bend-Zell silt loams, Hecla-Hamar loamy find sands, Stirom-Ulen fine sandy loams, Ulen fine sandy loams, and Ulen-Stirum fine sand loams have high potential for blowing. The potential for water erosion would be much less than for wind erosion. Measures to mitigate soil erosion are listed in Section 4.1.4—Mitigation Measures.

As described above for Tx-N, the most severe erosion at Tx-S site would occur during the first construction season. After that first year, soil would be covered by gravel or structures or revegetated, protecting it from wind and water erosion. During successive years, the vegetative cover would become more established, further reducing erosion potential. Thus, soil erosion

would be greatest during the 1991 construction season at the southeast and southwest sectors and during the 1993 or 1994 construction season at the east and west sectors. During those years, wind erosion at this site would be a significant impact.

Tx-S has a maximum elevation difference of 25 ft, and slope gradients are less than 2%. Site preparation would level the site, primarily by filling potholes and depressions. No significant topographic alterations would result.

Some of the Tx-S soils have high potential for shrink-swell behavior and would have severe limitations for road construction due to the potential for frost heaves. Some, but not all, of the on-site soils may not be suitable for use as fill because of their high clay content. Site soils would serve as one source of fill, and some would be imported from off site. The Air Force's preference would be to secure fill from a commercial borrow pit, if available. No known commercial operations near the site could supply that fill; however, the Coteau des Prairies, about 8 mi east of the site, could be a large source of sand and gravel. If existing commercial supplies were inadequate or uneconomical, the system contractor would develop an off-site borrow source. Environmental guidelines for selection of an off-site borrow source are given in Section 4.1.4 - Mitigation Measures.

Fill would be transported to the site by haul trucks with a capacity of 20 yd^3 each. The estimated maximum number of one-way truck trips would be 818 per day during site preparation for the initial two sectors. Those trucks could drag or spill earth on local roads, inconveniencing motorists.

No commercial mines for sand and gravel are located at or near the site. Therefore, the project would not affect access to mineral resources.

4.1.2 Receive Site

4.1.2.1 Rx-E

Construction at Rx-E would require site preparation similar to that described above for the transmit site. The area graded for construction of access and perimeter roads would be an estimated 57 acres and for construction of the antennas, groundscreen, and related facilities 470 acres. The total area subject to grading would be about 527 acres. Fill would be emplaced to raise the grade of depressed areas and to build elevated pads for structures and roads. The total fill volume would be about 1,122,000 yd^3. About 267 acres would be disturbed, and 567,000 yd^3 of fill would be emplaced during site preparation for the initial two sectors in 1991. About 260 acres and 555,000 yd^3 of fill would be affected during construction for the second two sectors in 1993 or 1994.

The areas of vegetation stripping and soil disturbance at Rx-E would have higher susceptibility to water and wind erosion. Most soils at the site would have slight erosion potential; however, areas of Vallers loam, Foldahl fine sandy loam, Syrene fine sandy loam, and Rosewood fine sandy loam would be highly susceptible to wind blowing. (Heschke, 1984) Portions of the site containing those sandy soils would be prone to development of blowouts. Measures to limit soil erosion are listed in Section 4.1.4. After the first year of site grading, site soil would be covered by gravel or structures or revegetated and erosion rates would diminish.

The maximum elevational change within the area of the Rx-E layout would be 30 ft. Slope gradients range from less than 1-2%. During site preparation, the site would be leveled, and existing depressions would be filled. No significant topographic alteration would result.

Rx-E soils would have low shrink-swell potential. The high likelihood of frost action, however, would be a constraint to road construction. Site soil would be suitable for use as fill, but some fill would be imported from off-site. It is estimated that a maximum of 644 one-way haul truck trips per day would be required for site preparation for the initial two sectors. Those trucks could drag or spill fill onto local roads, which would be an inconvenience to other motorists.

The Air Force's preference would be to obtain sand and gravel from a local commercial mine. Pennington County has 7 producers of construction sand and gravel, Polk County has 14, and Marshall County has 13 (Lipp, 1987). One of those suppliers probably could meet project needs for fill. If those producers are an inadequate or uneconomical source of fill, the system contractor could develop a new borrow pit. The beach ridges from glacial Lake Agassiz would be the largest natural supply of gravel in the area. Environmental guidelines for siting of a borrow pit are given in Section 4.1.4—Mitigation Measures.

There are no commercial sand and gravel mines at Rx-E. The project would not affect access to mineral resources.

4.1.2.2 Rx-W

Construction of receive facilities at Rx-W would require the removal of vegetation and soil disturbance on 527 acres. Approximately 57 acres would be graded for construction of 10 mi of perimeter road and 1 mi of access road. An additional 470 acres would be graded for construction of the groundscreen, antennas, support buildings, and related facilities. Fill volume emplaced for the perimeter and access road and the fence would be 186,000 yd^3. For the groundscreen and other structures, total fill volume would be 1,520,000 yd^3. Therefore, the total volume of filling would be 1,706,000 yd^3.

During construction of the initial two sectors in 1991, 267 acres would be graded and 865,000 yd^3 of fill would be emplaced. During construction for the final two sectors, about 260 acres would be disturbed and 841,000 yd^3 would be emplaced. Site soils would be loams and sandy loams that generally have low potential for water erosion. The Hamerly loam, Vallers loam, and Rockwell fine sandy loam, however, would be highly susceptible to wind erosion when stripped of vegetation. Measures to limit soil erosion are listed in Section 4.1.4—Mitigation Measures. After the first year of site grading, Site soils would be covered by gravel or structures or revegetated, and erosion rates would decrease.

The maximum elevation change across this site would be 20 ft. Slope gradients would be less than 1%. Site preparation would level the site and fill in low areas. No significant topographic alteration would result.

Rx-W soils have low potential for shrink-swell behavior. However, the high potential for frost action would be a limitation for roads. The soils on site would probably be suitable for use as fill, but some fill would be imported from off site. As noted above, many producers of construction sand and gravel operate in Marshall, Pennington, and Polk counties. Alternatively, the system contractor may develop a new borrow pit. The most likely location would be on one of the beach ridges of Glacial Lake Agassiz. Environmental guidelines for siting of borrow pits are listed in Section 4.1.4—Mitigation Measures.

Assuming that all of the required fill would be imported to the site by haul trucks with capacities of 20 yd^3 each, a maximum of 980 one-way haul truck trips would be required per day for site preparation for the initial two sectors. Those trucks could drag or spill soil onto local roads, inconveniencing local motorists.

Rx-W has no commercial sand and gravel mines. The project would not affect access to mineral resources.

4.1.3 Power Supply

4.1.3.1 Transmit Site

The installation of the poles for the power transmission line would cause some soil disturbance. The general procedure would be to auger a hole 10-20 ft into the ground, insert the pole, and backfill the hole with native soil or grout. Those operations would crush the vegetation and disturb the soil over an area of about 300 ft^2 for each H-frame structure and about 150 ft^2 for each monopole structure. Table 4.1.1 shows the area that would be disturbed in each link for H-frame and monopole structures. The number of H-frame structures required per link would vary from 26-216; the number of monopoles would be 18-152 per link. The area of soil

disturbance would be 0.20-1.49 acres per link for H-frames and 0.06-0.52 acres for monopoles. The maximum total length of the two powerlines would result from use of Links 1,3,5,6, and 9. For those links with H-frame design, 548 structures would be built and 3.78 acres of disturbance would result. For that worst case with monopole design, 385 structures would be required and 1.33 acres would be disturbed.

Table 4.1.1
AREAS OF SOIL DISTURBANCE FOR CRS TRANSMIT-SITE POWERLINE CONSTRUCTION

		H-frames Structures		Monopole Structures	
Link	Length (mi)	Number[1]	Acres Disturbed	Number[2]	Acres Disturbed
1	26.5	200	1.38	140	0.48
2	24.5	185	1.27	129	0.44
3	14.5	109	0.75	77	0.27
4	24.5	185	1.27	129	0.44
5	3.5	26	0.18	18	0.06
6	7.7	58	0.40	41	0.14
7	28.7	216	1.49	152	0.52
8	17.4	131	0.90	92	0.32
9	20.6	155	1.07	109	0.38
10	3.9	29	0.20	21	0.07

[1] Assumes average spacing of 700 ft.

[2] Assumes average spacing of 1,000 ft.

Source: SRI International.

The Forman and Groton substations will be expanded for the project. An area of 0.25 acre at each substation will be stripped of vegetation and leveled for pouring of concrete footings and

installation of equipment. At the CRS transmit site, about 1 acre will be stripped of vegetation and leveled for construction of a new substation.

Thus, a worst case estimate of the area of soil disturbance for construction of power lines and substations for the CRS transmit site is 5.28 acres. That area would be either stripped of vegetation and leveled (for substation installation) or disturbed by augering and heavy equipment movement (for tower erection). In either case, the native soils would be exposed to rainsplash, sheetflow, gully, and wind erosion. Because of the small total area and its wide distribution over a 55-mi stretch of land, erosion impacts would be extremely localized and minor.

The erosion potential is low throughout the powerline study area, but some links have greater erosion potential. Links 1,5,7, and 8 include areas of wind-blown silt and fine sand that would be prone to wind erosion—the most severe erosion hazard of the study corridors. Additionally, Links 4 and 7 contain sloping to hilly areas of glacial topography with relatively large relief. Those areas could be moderately prone to gully and overland flow erosion. The overall significance of soil erosion at the powerline construction areas, however, would be minor due to the generally flat terrain throughout the study area. Measures to mitigate soil erosion are included in Section 4.1.4—Mitigation Measures.

No deep cutting or filling would be required for powerline and substation construction. Topographic alteration would be extremely limited. Throughout most of the transmit-site powerline study area, the hazard to powerline structures from slope instability and erosion would be negligible. The only areas of moderate slip where instability could result from construction disturbance are the steeper parts of Links 4 and 7. Maximum slope gradients would be 8% at those areas, and the hazard level would be low.

Small amounts of surplus soil will be generated at each tower location after construction is completed. For both H-frames and monopoles, about 3 yd^3 of soil would be generated and disposed of in the immediate vicinity. Where structures are sited at or near wetlands, local disposal

of excess soil could cause turbidity and sedimentation effects on water bodies, ditches, or natural channels.

The only economic mineral resources in the powerline study area are sand and gravel. Construction of the CRS power line along existing roads would not hinder mining of sand and gravel. If the power line were to cross areas without roads, active mines would be avoided.

4.1.3.2 Receive Site

Construction of the receive-site powerline would require the same actions as described above for the transmit power lines. This powerline could be mounted on 35-45-ft high wooden poles spaced at 270-ft intervals, except for the final 0.5 mi near the site, where it will be placed underground. Alternatively, the powerline may be placed underground for its entire length. Table 4.1.2 lists the areas that would be subject to soil disturbance for each alternative corridor, assuming 150 ft^2 of land disturbance for each pole and a 15-ft wide strip of disturbance for underground construction. Within the 15-ft strip, a trench up to several feet wide would be excavated and vegetation on either side of the trench would be crushed by heavy equipment.

Either the Radium, Dakota Junction, or Morris-Owen substation would be upgraded for power supply to CRS receive site. That upgrade could include the installation of new equipment, but little, if any, new land would be affected. As shown in Table 4.1.2, the area of ground disturbance for an aerial power line to Rx-E would be about 2 acres, depending on the corridor used. Construction of a fully underground powerline would result in soil disturbance over about 24-27 acres. For an aerial powerline to Rx-W, about 1 acre would be disturbed. Construction of a fully underground line would disturb about 9 acres. For all the corridors under consideration, soils are more susceptible to wind erosion than water erosion. The poles would be inserted deep enough in the ground to prevent adverse effects from frost action or shrink-swell behavior. The corridors cross nearly flat terrain and no significant topographic alteration would be needed for power line construction.

Table 4.1.2
AREAS OF SOIL DISTURBANCE FOR CRS RECEIVE-SITE POWERLINE CONSTRUCTION

Corridor	Length[a] (mi)	No.of Poles	Acres Disturbed	Acres Disturbed for Undergrounding[b]	Total Disturbed Acres[b]
Dakota Junction-Rx-E	13.26	250	0.86	0.90/24.11	1.76/24.11
Morris-Owen-Rx-E (north line)	13.38	252	0.87	0.90/24.32	1.77/24.32
Morris-Owen-Rx-E (south line)	14.91	282	0.97	0.90/27.11	1.87/27.11
Radium-Rx-W	4.92	87	0.30	0.90/8.95	1.20/8.95

[a] Includes portion of corridor within concentrated study area

[b] 0.5 mi of underground powerline/entire powerline underground

SOURCE: SRI International

Excess soil will be generated by auguring for pole installation and trenching for underground installation. If improperly disposed of near or in water channels, the soil could cause adverse water quality and sedimentation impacts on those channels.

Powerlines will be located in rights-of-way (ROWs) adjacent to existing public roads. No impacts would occur on existing mines or pits. The powerlines also would not prevent future extraction of sand and gravel.

4.1.4 Mitigation Measures

4.1.4.1 General

The following mitigation measures are applicable to transmit, receive, and powerline sites. Implementation of measure M4.1.5 would be necessary to prevent significant impacts from development of off-site borrow pits, if necessary. Similarly, measures M4.1.8 and M4.1.9 would prevent significant impacts from the transmit-site powerlines.

M4.1.1— To reduce the potential for soil erosion impacts, a sediment and erosion control plan will be developed and implemented and will include measures M4.2.4, and M4.2.6 listed in Section 4.2.4 below. Additional elements of the plan include: limit clearing to the area to be used that season; minimize clearing near water bodies; stockpile soil for later use in revegetation; use dikes, berms, and silt curtains to minimize erosion; dispose of grubbed material away from water bodies; and grade slopes and embankments to stable gradients.

M4.1.2 — To minimize wind erosion of soil, construction areas stripped of vegetation would be sprinkled daily with sufficient water to keep the surface moist [estimated at 2.5 gallons per day (gpd) per yd^2]. Based on the area to be stripped of vegetation, daily watering of the transmit and receive sites would require about 1 million gpd at each site. Because that amount of groundwater would probably not be available, water would be selectively applied to those portions of site generating the most dust.

M4.1.3 — To reduce wind blowing of soil in stockpiles, stockpiles would be covered with tarpaulins when not in use. Also, to reduce the potential for impacts on wetlands, stockpile should be placed in upland areas away from wetlands.

M4.1.4 — To minimize export or import of soil to the construction sites, maximum use would be made of native soil as fill. Cut material should be reused on site wherever feasible.

M4.1.5 — To reduce environmental impacts, borrow would be obtained from existing pits to the extent feasible. If new sources must be developed, the following guidelines would be used to site new borrow pits:

- Avoid known wetlands, floodplains, and areas of ponding. Establish a 100-ft buffer zone to protect such areas from impacts
- Avoid areas of known cultural resource sites and historic properties
- Avoid areas of high wildlife concentrations or critical habitat
- Avoid areas containing special status plant species, including native prairie
- Minimize the distance from the borrow source to the construction site.

M4.1.6 — To obtain adequate sources of fill if commercial supplies are inadequate, borrow would be removed from the nearest feasible area.

4.1.4.3 Applicable to Rx-E and Rx-W

M4.1.7— To obtain adequate supplies of fill if commercial supplies are inadequate, borrow would be obtained from existing private stockpiles.

4.1.4.4 Applicable to Powerlines

M4.1.8 — To prevent sedimentation of channels, surplus fill from tower construction would be disposed of at least 100 feet from the nearest natural or manmade water channel.

M4.1.9 — To reduce the potential for soil erosion, Links 4 and 7 would be avoided if possible during powerline siting for transmit site.

4.2 HYDROLOGY AND WATER QUALITY

4.2.1 Methodology

This section, with the exception of Section 4.2.4 on the hydrology of powerline corridors, is based on Technical Study 4, Central Radar System Over-The-Horizon Backscatter Radar Program,

Hydrology and Water Quality, prepared by Metcalf & Eddy/Holmes & Narver (1990D). That study examined the potential for CRS facilities to affect flow patterns and volumes of surface and subsurface water and the quality of those waters.

The potential for flooding of CRS facilities is analyzed by determining the upstream area draining onto the CRS sites and calculating runoff volumes. The potential for CRS facilities to increase downstream flooding hazards was analyzed by calculating the change in runoff from the constructed CRS site based on an increase in impervious area, loss of detention capacity, loss in conveyance capacity of ditches and natural stream channels crossing the site, and modifications to existing drainage patterns. Surface water runoff volumes are calculated using methods described in the U.S. Soil Conservation Service (SCS), Technical Release Number 20, Project Formulation – Hydrology (TR-20, 1982). TR-20 uses procedures given in the SCS National Engineering Handbook, Section 4, "Hydrology."

Effects on groundwater supply were analyzed by determining the aquifer recharge areas covered by CRS facilities, the increase in recharge likely to result from installing gravel mats, and project-related groundwater pumping.

Effects on surface and groundwater quality could result from disposal of wastewater, leakage of hazardous materials and fuels on site, and corrosion of the antenna groundscreens. The likelihood and possible severity of those effects are also analyzed in this section.

4.2.2 Transmit Site

4.2.2.1 Tx-N

Drainage and Flooding—Construction of the CRS transmit antennas and related facilities would create impervious surfaces, such as building roofs, and concrete footings for antennas, and surfaces with reduced permeability, such as the compacted soil underneath the ground screen, the parking areas, and the perimeter roads. Additionally, the project would change overland flow patterns for runoff and site slope gradients. These changes would affect soil infiltration by precipitation and the time it takes for runoff to flow off site.

After construction, the overland flow path for Tx-N runoff would go around the groundscreens and antennas, because the site would be graded to provide gradients away from those facilities. Grading of the exclusion area would be minimal unless the area is used for borrow, and overland flow across that area would not be significantly affected. The perimeter roads would be elevated above the adjacent terrain and would be a barrier to overland flow. As a result, runoff would be expected to collect adjacent to the roads and flow parallel to roads. Culverts would be installed as necessary to allow runoff to flow under the roads and to prevent substantial accumulations of runoff.

The general flow direction of site runoff would be to the south, with runoff at the east and west sectors flowing southward parallel to the long axis of those facilities. The southeast and southwest sectors would be nearly perpendicular to the overall flow direction, causing runoff to flow nearly east-west for a short distance to travel around the antennas. The runoff would then continue its southward flow to the south of the southeast and southwest sectors and collect at the southern, particularly the southeastern, portion of the site.

The Air Force engineering design standard is the 25-year, 24-hour rainfall. Based on SCS data, that is 4.2 in at Tx-N. It is assumed that the overall slope gradient at each groundscreen area would increase from approximately 0.4 to 0.5% due to facility construction. At most of the remaining area, such as areas within the exclusion zone but outside the groundscreen area, slope gradients would not be altered. The time of concentration (time required for runoff to flow from most distant portion of the sector to the runoff outlet) for a typical sector (roughly 500 acres), would increase slightly from 2.73 to 2.87 hr because of the change in flow patterns. The increase in concentration time would decrease the peak discharge rate from that sector from the existing 315 cubic feet per second (cfs) to a post-construction 300 cfs.

The upstream drainage area that would drain onto the southwest transmit sector at Tx-N would be about 3 mi^2. During the 25-yr, 24-hr storm, the peak flow onto the site would be about 750 cfs. The other three sectors would have smaller upstream drainage areas and would receive smaller

off-site flows. Because of the large amount of runoff flowing across the southwest sector, one or more channels would be needed to direct runoff around the facilities.

The project would require grading of a large portion of Tx-N to prepare the ground surface for road, antenna, and building construction. Site preparation and gravel emplacement would eliminate wetlands that currently detain and store runoff. The volume of flood storage capacity that would be eliminated would be as much as 670 acre-ft. That volume will be compensated for by construction of drainage ditches and detention basins and by wetland mitigation. The detention basins will be sized to replace lost flood-storage capacity and will be designed to release runoff at roughly pre-construction flow rates.

The planned detention basins and drainage improvements would mitigate the reduction in flood storage capacity. No increase in runoff flow rates at the site boundary will result. Construction at Tx-N would not significantly alter drainage patterns or the locations of drainage divides. Runoff would not be transferred between watersheds by redirecting flow patterns.

Drainage channels can be grouped into the following categories: major channels of permanent streams, major ditches that are up to 20 ft wide and 10 ft deep, roadside swales that are up to 10 ft wide and 3 ft deep, and intermittent streams that transport water only during high runoff periods. The only known drainage channel at Tx-N is a ditch in the southwestern corner that connects to the Portage-Detroit Ditch, a tributary of the Crow Creek Drainage Ditch. Based on the proposed preliminary site layout, construction activity would avoid that ditch.

Wetlands—Construction at Tx-N would result in filling of depressions that seasonally retain water, as noted above. Thus, wetlands within construction areas (i.e., the antenna, building, road, and groundscreen areas) would be eliminated; those at the site not subject to direct construction would be fenced, but not physically disturbed. No significant changes in flow patterns or diversions of runoff across watershed boundaries would occur, and therefore no adverse effects on the hydrological balance of off-site wetlands would result.

Water Supply—One or more groundwater wells with a long-term operational pumping rate of about 0.5 gallons per minute (gpm) would be installed at each sector; thus, the combined pumping rate for the four sectors would be 2 gpm. During construction, however, water consumption would be up to 100,000 gpd and would require a combined yield of about 70 gpm from all four wells. The wells for the eastern and western sectors would probably draw from the James aquifer, which is 2-111 ft below the ground surface. The wells at the southeastern and southwestern sectors would probably tap the Dakota aquifer, which is 900-1,500 ft below the ground surface. Existing groundwater wells near the site yield up to 25 gpm. Therefore, during construction water demand would exceed the maximum known yield for local wells, possibly requiring other sources of water. Operational water consumption would be less, and no significant impacts would result.

The recharge area for the James aquifer includes portions of Tx-N. The reduction in soil infiltration due to the construction of impervious surfaces, however, would be offset by increased infiltration in areas of gravel emplacement. Calculations for surface runoff project that neither a net increase in runoff rate nor a net decrease in soil infiltration would occur. The project would not result in reduced recharge of the James aquifer.

The Dakota aquifer is recharged to the west of the transmit study area, and no recharge results from surface percolation at Tx-N. Construction of impervious surfaces at the site would not affect recharge of that aquifer.

Erosion and Water Quality—Soil erosion could result during construction due to the removal of vegetative cover and the exposure of bare soil to windsplash, overland flow, rill, and gully erosion and during operations due to the elevated grade of filled areas. Newly constructed ditches at the site would also be expected to suffer some bank and bed erosion until vegetation became established in those channels.

Soil particles eroded from the site would be transported by runoff to downstream areas, including ditches, culverts, natural channels, and pothole depressions, where some of the sediment

would be deposited. The sediment would increase the turbidity of those water bodies and could result in significant sedimentation. Increased turbidity could, if substantial, decrease the suitability of that surface water for domestic, irrigation, and wildlife use.

Wetlands near Tx-N are generally surface depressions collecting runoff from the surrounding terrain. Water within those wetlands flows slowly or is stagnant, which promotes deposition of eroded sediment carried by runoff. As as result, wetlands near Tx-N could be susceptible to deposition of soil eroded from the CRS construction site. Implementation of erosion control measures and direction of site runoff into through-flowing ditches and streams would reduce the potential for sedimentation impacts on wetlands.

Sedimentation of natural and man-made channels near Tx-N would reduce the cross-sectional area of those channels, thereby decreasing their flow capacity. Sediment accumulation could partially or completely clog culverts under roadways. The decreased capacities of ditches, natural channels, and culverts could result in more frequent overflow of channel banks and higher flood levels, exacerbating the flood hazards in the area immediately downstream from the site. The Crow Creek Drainage Ditch has a large capacity to convey flows and receives runoff from a large drainage area; therefore, sedimentation effects from the site would not be expected to affect that ditch significantly. The on-site ditch in the southwestern portion of the site and the Portage-Detroit Drainage ditch, however, could be adversely affected by eroded soil.

Wastewater treatment and disposal facilities would consist of a septic holding tank or septic tank with leach fields. A holding tank would be emptied into a truck periodically for removal to a treatment plant. No adverse effects on groundwater would result unless a spill occurred during transfer of the sewage, which is unlikely. A septic tank and leach field system would be designed and installed in conformance with Standards of the SDDWNR, which are designed to prevent groundwater contamination. The standards require that the wastewater treatment system have adequate capacity to filter and dispose of the effluent, given site-specific soil and groundwater conditions. Of the 11 soil series present on the site, four would pose limitations for siting a septic system, primarily because of shallow groundwater, increasing the importance of proper design,

installation, and operation of septic system conforming with the state guidelines. No adverse impacts on water quality would be expected.

Hazardous materials, such as lubricants, surface primers, paints, herbicides, and fuels, would be used during construction. During operation, diesel fuel, herbicides, cleaning fluids, and lubricants would be temporarily stored and used on site. The wastes would be transported and stored on site in accordance with a site-specific Spill Prevention, Containment, and Countermeasure (SPCC) Plan that will be prepared for CRS and reviewed by the EPA and state authorities. The plan will include measures to ensure safe storage and use of hazardous materials on site and contingency plans to respond to an accidental release. Hazardous wastes generated on site would be stored temporarily in EPA-approved containers and transported off site for disposal or treatment at an EPA-authorized site, probably at Grand Forks AFB, by an EPA-approved contractor.

4.2.2.2 Tx-S

Drainage and Flooding—Construction of CRS facilities at Tx-S would create impervious and nearly impervious surfaces and alter runoff flow patterns as described above for Tx-N. Postconstruction drainage patterns at the would be modified, but the existing boundaries of on-site watersheds would be maintained. The east sector and the northern half of the southeast and west sectors would drain northward into the intermittent channel and the large depression at the northern edge of the site (Sections 15 and 16, T125N, R59W). The southwest sector and the southern portions of the west and southeast sectors would drain southward into the intermittent stream at the southern portion of the site (Section 28, T125N, R59W). As would occur at Tx-N, runoff would generally flow parallel to each of the antennas and perimeter roads.

The 25-yr, 24-hr rainfall total for Tx-S is 4.2 in. The average slope of the groundscreen area would be increased during construction from 0.2 to 0.5%, which would decrease concentration time from 2.79 to 2.22 hr for a typical sector. At most of the site outside the groundscreen area, slope gradients would not be altered. As a result of the increase in impervious surfaces and the

decrease in concentration time, the peak runoff from a typical sector would increase from the existing 390 cfs to 460 cfs. To prevent the increase in runoff from flowing off site, about 15 acre-ft of detention capacity for each sector, or a total capacity of 60 acre-ft for all four sectors, would be required.

The upstream area that would contribute runoff to Tx-S is estimated at about 67.5 mi^2, most of which would be to the east between the site and the Coteau des Prairies. The west sector would experience the largest off-site runoff flow rate. Peak flow from upstream areas onto that sector during the 25-yr, 24-hr storm would be 1,220 cfs.

Construction at Tx-S would result in filling of wetlands and depressions that store flood waters. About 1,700 acre-ft of flood storage capacity would be lost. The loss of flood-storage capacity will be mitigated through construction of detention basins and drainage ditches and through wetlands compensation. The detention basins will be sized to replace the lost storage capacity and designed to release runoff at roughly pre-construction rates. The planned mitigation measures, detention basins and ditches, would prevent increased runoff flows across the site boundary. Drainage divides and drainage patterns will not be significantly altered.

Tx-S includes many major ditches, roadside swales, and intermittent swales that could be modified or destroyed by construction. The preliminary site layout would affect 1,500 ft of major ditches, 12,000 ft of roadside swales, and 18,000 ft of intermittent streams. Those ditches, swales, and stream channels currently collect on-site runoff and convey upstream flows across the site to downstream areas. Those functions will be replaced by drainage ditches to be built at the site. If the new ditches have sufficient capacity to collect upstream flows and the higher on-site flows and to convey the total peak flow rate downstream, no adverse impacts on drainage of upstream areas or the site would result.

Wetlands—Runoff flows onto Tx-S from the west, north, and east and flows off the site to the north and the south. Because of the relatively complicated flow patterns, construction of new drainage facilities that would fully maintain those patterns would be difficult. Although runoff

would continue to be routed across the site and discharged to both the depression to the north and the intermittent stream to the south, modifications to the area draining in each direction would probably result. Disruptions to established drainage patterns would occur at portions of the site and could affect small wetland areas at or near the site. Reduction in drainage area could decrease the amount of runoff reaching an individual wetland area, thereby adversely affecting its viability as a wetland.

Water Supply—CRS would require installation of one groundwater well at each sector. During project construction, the combined water requirement would be 50,000-1000,000 gpd. During operation, water needs would decrease, and the pumping rate for all four wells would decline to 2 gpm. The wells would draw from the Dakota aquifer 900-1,500 ft below the ground surface. The pumping rate during both CRS construction and operation would be somewhat below the yields of many other wells in the vicinity drawing from the Dakota aquifer. No adverse drawdown effects on that aquifer would result.

The Dakota aquifer is recharged from other aquifers located to the east and west of the site. The project would not affect such recharge.

Erosion and Water Quality—Soil erosion at Tx-S would be similar to that described above for Tx-N. Graded areas would be stripped of vegetative cover and exposed to rainsplash, overland flow, and gully erosion. Newly constructed ditches would transport substantial quantities of water and would be subject to bank and bed erosion.

Eroded soil would be washed to downstream areas, potentially causing sedimentation of wetlands, ditches, and stream channels. Increased turbidity could affect the water's suitability for domestic, irrigation, or wildlife use. As described for Tx-N, small wetlands may be particularly susceptible to sedimentation effect. Measures implemented to control erosion during construction and development of adequate drainage facilities would mitigate those impacts.

Sedimentation of ditches, culverts, and wetlands could decrease their capacity to convey and store runoff, thereby increasing local flood hazards at areas immediately downstream, including

the intermittent stream at the southern site boundary and the depression north of the site. Sedimentation of the intermittent stream could be a more significant impact than sedimentation of the depression because of the depression's large size. Loss of that stream's conveyance capacity could affect drainage of nearby fields.

Impacts from wastewater treatment and disposal and temporary storage of hazardous materials would be the same as described above for the northern transmit site. Of the 21 on-site soil series, 14 would pose severe limitations for septic system siting. The major problems would be low soil permeability and a high groundwater table.

4.2.3 Receive Site

4.2.3.1 Rx-E

Drainage and Flooding - The 25-yr, 24-hr rainfall at Rx-E is approximately 4 in. For a typical sector, the ground slope gradient would increase from 0.2 to 0.5%, and concentration time for runoff would decrease from 1.4 to 0.74 hr. Those changes and the construction of impervious surfaces on site would increase the peak runoff rate for a typical sector (roughly 160 acres) from 180 to 280 cfs, Assuming that the other three sectors would cause a similar increase in peak runoff flow rate, the storage volume required to attenuate the total increase would be 32 acre-ft.

In preliminary site layout at Rx-E, the east and west sectors are located in the center of the site, with the southeast sector to the north and southwest sector to the south. Runoff would generally flow westward and southward across the site, parallel to the perimeter roads around each antenna. All runoff would eventually flow to the extreme southwestern corner of the site and into the existing intermittent stream at that location (Section 30, T154N, 45W).

The site and vicinity are within the watershed of Judicial Ditch 25, which is located east and south of Rx-E. The west sector would receive the greatest flow of off-site runoff, from 1.75 mi^2

of off-site land. During the 25-yr, 24-hr storm, peak runoff onto the west sector would be about 800 cfs.

The project would result in filling of wetlands, thereby reducing the available capacity on site for storage of upstream flows. Lost storage capacity would be about 38 acre-ft. Thus, construction would increase the peak flow rate for runoff generated on site and would reduce the amount of on-site storage capacity available to detain peak flows. Those effects would be mitigated by construction of detention basins and drainage ditches to control runoff at the site. The detention basins would be sized to replace lost flood-storage capacity and designed to release runoff slowly at pre-construction flow rates.

Based on the preliminary site layout for Rx-E, about 300 ft of major ditches, 600 ft of roadside swales, and 9,000 ft of intermittent streams would be modified. New drainage improvements would be constructed to substitute for the modified drainage. If the new improvements have about the same capacity as the existing ditches, swales, and channels, no significant adverse effects would occur.

Wetlands—Construction would require filling of some on-site wetlands. The major site drainage patterns would be retained, however, and no diversion of water from one watershed to another is expected. Thus, the hydrologic balance of off-site wetlands would not be affected, and no adverse impacts on off-site wetlands would result.

Water Supply—As for the transmit sites, groundwater wells at each sector would be installed. During construction, the total pumping rate could be as much as 70 gpm. During operation, each well would pump at 0.5 gpm; the total pumping rate for four wells would be about 2 gpm. Existing groundwater wells in the vicinity yield 10 to 150 gpm so the new wells should be able to supply project water needs.

At Rx-E, small lenses of coarser sediments collect limited amounts of groundwater and are probably recharged by direct infiltration of precipitation. New impervious surfaces would reduce

infiltration slightly and could affect the recharge of groundwater supplies, but because only a small area would be covered, the effect would be minor.

Erosion and Water Quality—Soil erosion would be expected at Rx-E in areas stripped of vegetation and within the channels of newly constructed drainage ditches. Eroded soil would be washed into the intermittent stream southwest of the site and eventually into Judicial Ditch 25. That would increase the turbidity of water in those channels, would have adverse aesthetic impacts, and could reduce the water's suitability for domestic, irrigation, and wildlife use. Additionally, sedimentation of the intermittent stream could reduce its peak flow capacity, potentially increasing the frequency and severity of downstream flooding. Wetlands in the area could be subject to adverse impacts from deposition of eroded soil. Implementation of best management practices to reduce soil erosion on site would reduce the severity of these impacts.

Potential impacts from wastewater treatment and disposal and temporary storage of hazardous materials would be the same for Rx-E as described above for the preliminary transmit-site layouts. All site soils would pose severe limitations to septic systems siting. The primary limitations would be soil wetness and ponding of runoff.

Rx-E soils tend to be corrosive to metals. The groundscreen could be prone to oxidation, thus introducing ferrous metals into surface and groundwater. Proper drainage of the groundscreen or use of aluminum coated steel or stainless steel for groundscreen construction would minimize corrosion. No significant impact on groundwater quality would be expected.

4.2.3.2 Rx-W

Drainage and Flooding—The 25-yr, 24-hr rainfall at Rx-W is approximately 4 in. For a typical sector, the ground slope gradient would increase from 0.3 to 0.5% at the groundscreen and concentration time for runoff would decrease from 1.33 to 0.74 hr. Those changes and the addition of impervious surfaces would increase the peak runoff rate from 200 to 290 cfs. Assuming that the other three sectors would involve similar changes, an estimated 36 acre-ft of detention capacity would be required to prevent an increase in downstream runoff.

Drainage patterns would not be altered significantly by construction. Runoff from the southern portion of the site would flow northward along either side of the back-to-back east and west antennas and then westward to the unnamed ditch at the northeastern corner of Section 19, T154N, R46W. Runoff from the northern portion of the site would flow roughly east-west along the sides of the southeast and southwest antennas and then northward to the branch of Judicial Ditch 25 at Section 16, T154N, R46W.

Rx-W receives runoff from the areas to the east that are upslope from the site. The west sector would receive a peak runoff flow rate of 1,650 cfs from an upstream area of about 10.5 mi. One or more channels will be constructed to route that flow around the site.

Small areas of wetlands could be filled during construction. Approximately 10 acre-ft of on-site flood storage capacity would be eliminated. That loss of flood storage capacity would be mitigated by construction of detention basins and drainage ditches. The detention basins would be sized to replace the lost storage capacity and designed to release runoff at roughly preconstruction flow rates.

Construction would not alter or destroy any existing major ditches, roadside swales, or intermittent streams. Some on-site wetland areas would be filled. Because diversions of water flow would not be substantial, effects on the hydrologic balance of downstream wetlands would not be significant.

Water Supply—Groundwater wells with an average pumping rate of 0.5 gpm at each sector would be sufficient for normal CRS operation; total pumping would be about 2 gpm. Two existing public wells in the vicinity have a total yield of 300 gpm. Thus, the aquifers at Rx-W should be capable of meeting CRS water needs.

Groundwater recharge is assumed to be by infiltration of precipitation. The project would cover portions of the site with impervious and nearly impervious surfaces, decreasing the amount of infiltration. However, the area of impervious surfaces would be small and most of the site would not be covered by impervious surfaces; so the impact would not be significant.

Erosion and Water Quality—Soil erosion would occur on the disturbed portion of Rx-W, as described above for Rx-E. Eroded soil would be washed into the unnamed drainage ditch west of the site and the branch of Judicial Ditch 25 to the north. Increased turbidity of that water could reduce its suitability for domestic, irrigation, and wildlife use. Wetlands near the site could be affected by deposition of eroded sediment. Additionally, sedimentation of ditches, streams, swales, and culverts could reduce their capacity to transport peak flows, increasing flood hazards. Implementation of erosion control measures during construction at the site would mitigate those effects.

Potential impacts on water quality from wastewater treatment and disposal, temporary storage of hazardous materials, and corrosion of the groundscreen would be the same at Rx-W as described for Rx-E. All site soil would pose severe limitations for septic systems due to soil wetness.

4.2.4 Power Supply

4.2.4.1 Transmit Site

Construction of the two 115-kv powerlines and the expansions of the Groton and Forman substations could affect water bodies, drainage patterns, and water quality. Any effects would be distributed out along the selected powerline route, reducing the significance of impacts occurring at any particular location.

The Groton Substation is located about 2,000 feet east of a tributary stream that flows northward to Mud Creek, about 1.5 mi north of the substation. Substation expansion would not affect that tributary stream. Substation construction would create about 0.25 acres of impervious surface, consisting of concrete footings and gravel surfaces. That impervious area would be insufficient to a significantly increase runoff volumes. Soil erosion could occur during construction, but due to the small area exposed, the short duration of that exposure (less than 8 months), and the distance to the nearest water body (about 2,000 ft), sedimentation and water

quality effects would be minor. Likewise, potential water contaminants, such as paints, cleaners, and surfactants, would be used during construction, but given the distance to the nearest water bodies, no contamination would be expected.

The Forman Substation is located in an area of numerous closed depressions which collect runoff to form temporary or seasonal wetlands. Runoff from the substation and vicinity generally flows into local depressions and dissipates due to evaporation, evapotranspiration, and soil infiltration. The creation of 0.25 acres of impervious surface area would have negligible effects on runoff rates and drainage patterns. No natural or man-made channels would be affected. Soil erosion would occur over that area during the 8-month construction period. Minor sedimentation of nearby depressions could result. Accidental release of paints, cleaners, etc., during construction could degrade water quality but because only small amounts of possible contaminants would be used, any impact would not be significant.

Expansion of the Forman substation would occur in an area with numerous wetlands. Depending on the precise siting of the substation, it would be possible to locate the expansion so that no wetlands would be filled.

Powerline construction would result in installation of up to 548 transmission structures over 73 mi. At each structure, about 300 ft^2 would be disturbed and compacted. Compaction could slightly increase the surface runoff rate by reducing the amount of soil infiltration. Soil erosion could also result at each structure site. However, the total area subject to soil compaction and erosion would be less than 5 acres spread over up to 73 mi. No significant effects on erosion and water quality would be likely.

Wetlands could be filled if transmission structures are placed in existing wetlands. Assuming that wetlands occur along the powerline route in the same proportion as they occur in each corridor, up to 5% of the transmission structures in links 1-4 could be located on wetlands. For example, that would be 15 structures if Links 1 and 3 are used. If 300 ft^2 were disturbed at each structure site, about 0.1 acre of wetland would be disturbed. At links 5-9, up to 239 structures

would be required. Based on the corridor-wide percentage of wetlands, up to 22 structures would be located in wetlands and 0.15 acres of wetlands could be filled. Link 10 contains 18% wetland; construction at that link could result in filling of 0.04 acre of wetland. The actual impact on wetlands from powerline construction would probably be less than estimated above because wetlands will be avoided by the powerline route as much as possible. Additionally, wetlands within the ROW can be spanned to eliminate impacts. Thus, no wetlands will be affected unless no alternatives are available.

Stream crossings are areas of high concern because of the potential to disturb the channels. Links 2 and 4 would cross many streams arising in the Coteau des Prairies; thus the potential for effects on channels would be greatest in those links. In most cases, powerline structures could be located to avoid stream channels.

4.2.4.2 Receive Site

Construction of the receive-site powerline would involve installation of up to 282 poles and undergrounding of 0.5 mi or more of powerline. The total area of ground disturbance and soil compaction would range from 1-9 acres for the 5-mile Rx-W corridor to 2-27 acres for the - Rx-E corridor. Because of the small area affected and its distribution over the line length, increases in surface runoff and erosion would be insignificant. No significant alterations to established drainage patterns would result.

The potential for disruption of wetland or stream channels due to powerline construction would be greater. All three corridors connecting to Rx-E cross an area with a high concentration of wetlands located in the beach-ridge area 5-7 miles west of Thief River Falls. Although most structures could probably be located on elevated upland areas, some would probably necessarily be sited within the wetlands. At most, about 60 poles would be erected within that 2-3 mile stretch. Based on a typical disturbance area of 150 ft^2 per pole, up to 0.2 acre could be disturbed for construction of the Rx-E powerline. Construction disturbance would include crushing or removal of vegetation, soil grading and compaction, and excavation for installation of poles. In

addition, the powerline connecting to the Dakota Junction Substation would cross the Thief River. Installing poles near that channel could result in bank disturbance and erosion.

The final 0.5 mi or more of the powerline connecting to the receive site would be installed underground to prevent interference with the antenna operation. To install the underground powerline, a 15-ft wide strip of land would be disturbed. At the center of the disturbed strip, a trench would be excavated, requiring removal of vegetation. The trench would be backfilled to its original grade, allowing revegetation. One either side of the trench, heavy equipment would crush vegetation. After construction is complete, the corridor could be revegetated. There are no major streams or drainage ditches in that portion of any of the alternative corridors However, small man-made ditches and wetlands could be temporarily disrupted by construction activities. The disturbed area would be returned to its original condition after construction is finished.

Alternatively, the entire receive-site powerline may be placed underground. That would result in a substantial increase in the area of soil disturbance and a higher potential for direct physical disruption of streams and ditches. Each alternative corridor crosses major ditches. In addition, the Dakota Junction corridor crosses the Thief River, and the Radium corridor crosses two branches of the Snake River. The erosion potential at the river crossings would be high.

The corridor connecting the Radium substation to Rx-W would cross tributary channels and the main and South branches of the Snake River. Wetlands cover only 1.5% of the corridor area and could probably be avoided during transmission structure siting. No disturbance of wetlands should result. Installation of transmission structures near the channel of the Snake River or its tributaries could result in bank disturbance and erosion. That impact could be avoided by locating transmission structures a sufficient distance from those channels. The electric cooperative serving the selected site will prepare a Borrower's Environmental Report for the CRS powerline. That report will examine potential hydrologic impacts of the powerline in more detail.

4.2.5 Mitigation Measures

The following measures would mitigate possible hydrologic and water quality effects. Implementation of measures M4.2.1, M4.2.2, M4.2.3, M4.2.7, M4.2.8, M4.2.9, M4.2.10, M4.2.12, M4.2.13, and M4.2.14 will be required to prevent significant impacts.

4.2.5.1 General Measures

M4.2.1 - To prevent an increase in downstream or upstream flood hazard at the transmit and receive sites, all on-site channels and ditches removed during construction should be replaced by drainage improvements of equal conveyance capacity. Ditches, swales, and culverts at each sector should have sufficient capacity to transport, without overflow, peak runoff from the upstream drainage area during the 25-yr, 24-hr storm. The peak flow rate from upstream areas could be calculated using methodologies outlined in TR-20 by the SCS or through a detailed hydrologic field study.

M4.2.2 - To minimize diversions of runoff from one basin to another and impacts on downstream wetlands, the grading and drainage plans for the transmit and receive sites will preserve and maintain existing drainage patterns. Runoff will not be transferred between basins because this could adversely affect the hydrologic balance of off-site wetlands. If interbasin transfers cannot be avoided, exchanges will be balanced to minimize hydrologic impacts.

M4.2.3 - To compensate for increased runoff generation and loss of on-site storage capacity, detention basins of sufficient size to replace lost storage capacity and to attenuate peak runoff flows to preconstruction levels will be constructed at each transmit and receive sector. The basins will minimize permanent accumulation of water, which could attract birds.

M4.2.4 - To reduce the likelihood of erosion, energy dissipation devices should be installed at inlets where runoff discharges into detention basins, streams, or ditches. To reduce erosion of ditches and swales, side slopes should be constructed at gradients of no more than 1 vertical to 2 horizontal and bank protection should be installed on the outer bank of sharp meanders.

M4.2.5 - To reduce the potential for soil erosion during construction, the Air Force will prepare, in advance of construction, a sediment and erosion control plan as described in measure M4.1.1. That plan will contain specifications for sediment control basins to remove eroded soil from site runoff.

M4.2.6 - To prevent soil erosion, vegetation removal at the transmit and receive construction sites should be minimized. Graded areas should be revegetated as soon as possible after construction.

M4.2.7 - To prevent contamination of soil or groundwater by hazardous materials used on site, the Air Force will prepare a SPCC in conformance with EPA and state regulations. That plan should describe Best Management Practices (BMPs) for storage, use, transport, and disposal of fuel and other hazardous materials. EPA-approved containers should be used for storage and transport of hazardous materials. Disposal should be at a federally licensed disposal site.

4.2.5.2 Measures Applicable to Tx-N and Tx-S

M4.2.8 - To reduce the potential for groundwater contamination, facilities for wastewater treatment and disposal should be designed and built in conformance with applicable SDDWNR regulations. At Tx-N, septic systems should be located on Hecla-Hamar loamy fine sands, Hecla-Venlo complex, Maddock loamy fine sand, Serden fine sand or Serden-Venlo complex, as mapped by SCS. Tx-S, septic systems should be located on Beotia silt loam, Beotia-Bearden silt loams, Embden fine sandy loam, Great Bend-Boetia silt loams, Great Bend-Zell silt loams, Harmony-Aberdeen silty clay loams, or Hecla-Hamar loamy fine sands, as mapped by SCS.

M4.2.9 - If Tx-N is selected, capacity to convey about 750 cfs of upstream runoff around the site should be constructed at each sector. Additionally, a total of 670 acre-ft of detention capacity for runoff should be built on the site.

M4.2.10 - If Tx-S is selected, capacity to convey about 1,220 cfs of upstream runoff around the site should be constructed at each sector. Additionally, a total of 1,760 acre-ft of detention capacity for runoff should be built on the site.

4.2.5.3 Measures Applicable to Rx-E and Rx-W

M4.2.11 - To reduce the potential for groundwater contamination, wastewater treatment and disposal facilities should be designed and built in conformance with applicable MPCA regulations. The soils at both Rx-E and Rx-W are not suitable for conventional septic systems; the use of a mound system should be considered.

M4.2.12 - If Rx-E is selected, capacity to convey about 800 cfs of upstream runoff around the site should be constructed at each sector. Additionally, a total of 70 acre-feet of detention capacity for runoff should be built on the site.

M4.2.13 - If Rx-W is selected, capacity to convey about 1,650 cfs of upstream runoff around the site should be constructed at each sector. Additionally, a total of 46 acre-ft of detention capacity for runoff should be built on the site.

4.2.5.4 Measures Applicable to Powerlines

M4.2.14 - To prevent bank disturbance and erosion impacts on streams, powerline structures should be placed at least 100 ft from the top of the bank of natural channels.

M4.2.15 - The Forman Substation expansion will be located to avoid filling of wetlands designated on NWI maps.

M4.2.16 - To reduce the potential for adverse effects on water quality, the SPCC plan described in measure M4.2.9 above should be applied during powerline construction, as should measures 4.2.6 and 4.2.7 concerning erosion control.

M4.2.17 - To prevent construction disturbance of wetlands, the receive-site powerline structures and underground lines would be located outside of wetlands to the maximum extent possible.

4.3 AIR QUALITY

4.3.1 Overview

Air quality impacts are considered significant if state or federal thresholds for ambient concentrations of air pollutants or for total annual emissions are exceeded.

4.3.2 CRS Construction

During construction of the CRS, air pollutants would be generated primarily during clearing, bulldozing, grading, hauling, and other construction activities, and from fuel combustion by construction equipment, and vehicles, including supply trucks and worker's vehicles.

4.3.2.1 Fugitive Dust

The term "fugitive" refers to emissions that are discharged over a broad area rather than from a specific location. Winds greater than 12 mi per hour (mph), or about 5 meters per second (m/s), are required for substantial entrainment of dust (in the absence of mechanical disturbance). Based on meteorological data from Aberdeen, South Dakota, and Thief River Falls, Minnesota, winds of this magnitude occur about 35% of the time at both the transmit and receive study areas. Particles larger than 100 microns (μ) in diameter typically settle out of the air within about 20-30 ft of their source and generally are not considered to be fugitive dust. Particles greater than 30 μ in diameter are characteristic of construction emissions and settle out of the air within a few hundred feet of their source. Particles smaller than 30 μ, generally referred to as total suspended particulate (TSP), remain suspended in the air indefinitely; the State of Minnesota regulates emissions of TSP. The fraction of these particles smaller than about 10 μ (PM_{10}), referred to as respirable

particulate, are considered to pose potential human health risks and the federal National Ambient Air Quality Standards (NAAQS) applies.

Fugitive dust emissions would depend on site characteristics as given in Table 4.3.1. Travel of construction equipment and haul trucks over unpaved surfaces, earthmoving and materials-handling operations, and wind erosion of disturbed soil would generate fugitive dust. Site preparation would start with an undisturbed site would end with all bare areas covered with compacted gravel, poured foundations, or new vegetation.

Table 4.3.1
ESTIMATED SITE CHARACTERISTICS RELATED TO FUGITIVE DUST EMISSIONS

Alternative Site Layouts	2-Sector Grubbed Area (acres)	2-Sector Fill Volume (yd^3)	Silt Content of Soils (%)
Transmit			
Tx-N	262.5	431,500	42
Tx-S	255.5	717,750	23
Receive			
Rx-E	267	561,000	33
Rx-W	267	853,000	37

Source: SRI International.

Vehicle Travel Over Unpaved Surfaces—Emissions of PM_{10} by vehicle travel over unpaved surfaces were estimated using methodology given by Cowherd (1988) and EPA (1985). The worst-case situation for fugitive dust generation assumed in this analysis would have all construction vehicles traveling over unpaved dirt surfaces at the site. The construction vehicles that would be needed for site preparation are shown in Table 4.3.2 based on construction experience at the OTH-B West Coast Radar System (WCRS). The speed of all construction vehicles was

Table 4.3.2
POSSIBLE ON-SITE CONSTRUCTION VEHICLES FOR SITE PREPARATION [a]

Vehicle	Number	Weight (t)	No. of Wheels
D8 bulldozer	5	40	b
Pan scraper	3	40	6
Tandem dump	5	40	18
Grader	3	30	6
Roller	2	40	1
Front-end loader	3	15	4
Haul truck (loaded)	15	40	18
Haul truck (empty)	15	20	18
Water truck	2	20	10
Mobile crane	1	40	14
54-in. compactor	1	20	4
Wheeled compressor	1	20	4

[a] Based on experience at other OTH-B radar construction sites.
[b] This vehicle is tracked.

Source: SRI International.

assumed to average about 5 mph, except for on-site haul trucks and trucks transporting fill to the site, which were assumed to average 10 mph. Construction vehicles would operate for an estimated 6 hours per day (hr/d), or 30 vehicle miles traveled (VMT) per day. On-site haul trucks would travel 60 VMT per day, 30 mi of which would be with a load and 30 mi with no load. Calculations were made for Tx-S and Rx-W, because they would require the most filling and earth movement. PM_{10} emissions at Tx-N and Rx-E sites were estimated using the ratio of earth movement and soil silt content at those sites to that at Tx-S and Rx-W. The net result, shown in Table 4.3.3, is that vehicle-generated dust emissions would be about 10% greater at Tx-N than at Tx-S. Fugitive dust emissions would be about 71% greater at Rx-W than at Rx-E.

Table 4.3.3
PM_{10} EMISSIONS FROM ON-SITE CONSTRUCTION VEHICLES
(lb/day)

Vehicle	Tx-N	Tx-S	Rx-E	Rx-W
D8 bulldozer	227	207	195	333
Pan scraper	383	349	329	561
Tandem dump	1,106	1,008	951	1,621
Grader	285	285	269	459
Roller	104	95	90	153
Front end loader	157	143	135	231
Haul truck (loaded)	6,637	6,045	5,704	9,725
Haul truck (empty)	4,085	3,721	3,511	5,986
Water truck	185	185	174	297
Mobile crane	195	178	168	286
54-in. compactor	64	58	55	94
Wheeled compressor	40	36	34	58
Total	13,468	12,310	11,615	19,804

Source: ESA, Inc, 1990

In addition to the PM_{10} emission in Table 4.3.3, haul trucks bringing fill to the site and travelling over unpaved surfaces at the site would generate dust. The number of two-way trips by haul trucks required at each site would vary with the amount of fill to be imported and the distance over which the fill would be transported to the site. Table 4.3.4 lists the estimated PM_{10} emissions, based on an estimated 4 mi travel distance over unpaved surfaces at the site per trip.

Material-handling Activities—The handling of earth materials during site preparation and construction operations would also generate fugitive dust emissions. PM_{10} emissions from materials-handling operations were estimated using equations given in Cowherd (1988) and EPA (1985B), assuming moisture content of 10% for all transferred material. The estimates for dust emissions (PM_{10}) due to material transfers ranges from 3.5-5.6 lb/day, which would be negligible.

Table 4.3.4
PM_{10} EMISSIONS FROM HAUL TRUCKS TRAVELING OVER UNPAVED SURFACES

Alternative Site	Fill Volume Imported for Initial Two Sectors (yd^3)	One-Way Haul Distance (mi)	Maximum Two-Way Truck Trips Per Day	PM_{10} Emissions (pounds/day)
Transmit				
Tx-N	431,500	4	248	39,315
Tx-S	717,750	4	414	35,940
Receive				
Rx-E	561,000	4	322	61,033
Rx-W	853,000	4	490	68,431

Sources: SRI International; ESA, 1990

Earth Movement—Another source of fugitive dust emissions would be earthmoving operations such as bulldozing, scraping, and hauling. PM_{10} emissions due to bulldozing are also estimated using equations given by Cowherd (1988) and U.S. EPA (1985B). The total of bulldozer, scraper, and haul truck PM_{10} emissions would be 2,910 pounds per day (lb/d) for Tx-N and 4,961 lb/d for Tx-S. Bulldozer, haul truck, and scraper operations would generate PM_{10} emissions at Rx-E of 3,324 lb/d and at Rx-W of 5,096 lb/d.

Wind erosion—Another source of fugitive dust emissions is wind erosion of soil surfaces stripped of vegetation. PM_{10} emissions from wind erosion were calculated from the universal soil loss equation. (Cowherd, 1988 and EPA, 1985) As a worst-case estimate, the area cleared of vegetation for to build the initial two sectors would be 262.5 acres at Tx-N, 255.5 acres at Tx-S, and 267 acres at Rx-E and Rx-W. The resulting PM_{10} emission rates from wind erosion of exposed areas would range between 25,200- 25,890 lb/d for transmit site layouts and 20,482 lb/d for the receive site layouts.

The PM_{10} fugitive dust emissions that would result from all sources are summarized in Table 4.3.5.

Table 4.3.5
TOTAL PM_{10} FUGITIVE DUST EMISSIONS GENERATED DURING CRS CONSTRUCTION (lb/d)

Source	Tx-N	Tx-S	Rx-E	Rx-W
Vehicle travel[a]	52,783	48,250	72,648	88,235
Material handling	—	—	—	—
Earth moving	2,910	4,961	3,324	5,096
Wind erosion of soil	25,890	25,200	20,482	20,482
Total	81,583	78,411	96,454	113,813

a - Summed From Tables 4.3. and 4.3.4

Source: ESA,1990.

4.3.2.2 Construction Vehicle Emissions

Pollutant emissions from the construction-vehicle diesel engines were estimated using emissions factors developed by EPA (1985B). Table 4.3.6 shows the estimated emissions of heavy-duty diesel construction equipment. The numbers and types of equipment listed are representative of that used to build other, similar OTH-B radar installations, but actual equipment use would differ somewhat from this list. Each piece of equipment was assumed to operate 8 hr/d.

Truck engine emissions are estimated using EPA emission factors for heavy-duty diesel trucks. It was assumed that haul trucks would average 10 mph and tandem dump trucks and water trucks 5 mph. It was also assumed that the trucks would spend 2 hr/d at idle and 6 hr/d in motion.

Table 4.3.6
EXHAUST EMISSIONS FROM HEAVY-DUTY CONSTRUCTION EQUIPMENT (lb/d)

Vehicle Type	No. of Vehicles	Carbon Monoxide (CO)	Hydro-carbon (HC)	Nitrogen Oxides (NO_x)	Sulfur Oxides (SO_x)	Particulates (PM_{10})
Bulldozer	5	71.9	7.64	166	18.1	10.2
Pan scraper	3	30.0	6.77	92.0	11.1	9.72
Grader	3	3.61	0.95	17.1	2.06	1.46
Roller	2	4.86	1.08	13.8	1.07	0.80
Front-end loader	3	13.7	5.98	45.3	4.36	4.11
Other[a]	3	16.2	3.66	40.5	3.42	3.34
Total		140	26.1	375	40.1	29.6

Note: Totals rounded to three significant digits.

[a] Equipment in this category is a 15-t mobile crane, a 54-in. vibratory compactor, and a wheeled compressor.

The calculated truck emissions are shown in Table 4.3.7. Total emissions from truck and construction-equipment diesel engines would be as follows: CO, 199 lb/d; HC, 81.4 lb/d; NO_x, 393 lb/d; SO_x, 40.6 lb/d; and PM_{10}, 31 lb/d.

Haul trucks importing fill to the site and vehicles operated by construction personnel commuting to the site would also have emissions. Round-trip distances for haul trucks are estimated at about 50 mi for Tx-N and Tx-S and 20 mi Rx-E and Rx-W, leading to the emission rates shown in Table 4.3.8. Those emissions would be distributed over the travel route between the borrow source and the construction site.

A maximum of 220 construction workers would commute during site preparation. Based on EPA automobile emission factors and an average speed of 50 mph, the exhaust emissions from workers automobiles for various round-trip commuting distances would be as indicated in Table 4.3.9. Total exhaust emissions from construction equipment, haul trucks, and automobiles are shown in Table 4.3.10.

Table 4.3.7
ON-SITE TRUCK EXHAUST EMISSIONS
(lb/d)

Vehicle Type	No. of Trucks	CO	HC	NO_x	SO_x	PM_{10}
Tandem dump	5	10.8	8.94	3.02	0.069	0.187
Water trucks	2	4.3	3.58	1.21	0.412	1.123
Haul trucks	15	44.0	42.8	13.5	0.028	0.075
Total		59.1	55.3	17.7	0.513	1.385

Source: ESA, 1990

Table 4.3.8
OFF-SITE HAUL TRUCK EXHAUST EMISSIONS
(lb/d)

Alternative Site	CO	HC	NO_x	SO_x	PM_{10}
Transmit					
Tx-N	183	71	374	5.78	15.6
Tx-S	303	118	621	9.59	25.9
Receive					
Rx-E	117	45	239	3.70	9.98
Rx-W	179	130	366	5.66	15.3

Source: ESA, 1990.

Table 4.3.9
EXHAUST EMISSIONS FROM WORKERS AUTOMOBILES

(lb/d)

Round-Trip Distance (mi)	CO	HC	NO_X	SO_X	PM_{10}
20	45.8	8.35	12.0	2.03	1.06
35	80.1	14.6	21.0	3.56	1.85
50	114.4	20.9	30.0	5.08	2.64

Source: ESA, 1990

Table 4.3.10
EXHAUST EMISSIONS DURING CRS CONSTRUCTION
(lb/d)

Vehicle Category	CO	HC	NO_X	SO_X	PM_{10}
Construction equipment	140	26	375	40.1	29.6
On-site trucks	59	55	18	0.5	1.4
Off-site trucks [a]	303	118	621	9.6	25.9
Automobiles [b]	114	21	30	5.1	2.6
Total	616	220	1,044	55.3	59.5

[a] Uses Tx-S as worst case.

[b] Private automobiles used by workers for commuting, assuming a 50-mi round trip travel distance.

Source: ESA, 1990

4.3.2.3 Dispersion of Pollutants

The EPA-approved Industrial Source Complex (ISC) Gaussian plume model was used to calculate the dispersion of pollutants emitted at the rates estimated above. Dust-generating site preparation activities would peak in September of each construction period. At both transmit and receive sites, September wind would typically be from the south, at an and the average speed of 11 mph. PM_{10} emissions would be up to 81,583 lb/d at Tx-N; 78,411 lb/d at Tx-S; 96,454 lb/d at Rx-E; and 113,813 lb/d at Rx-W.

The PM emission rate is estimated at 81,583 lb/d at Tx-S. The average 1-hr ground-level PM_{10} concentration at the downwind edge of the site would be about 1,760 $\mu g/m^3$. The federal NAAQS for 24-hr PM_{10} concentrations is 150 $\mu g/m^3$. PM_{10} concentrations would fall below 150 $\mu g/m^3$ at about 2.9 mi downwind from the site. Wind shifts over a 24-hour that period could assist dispersal of the PM_{10} emissions and could reduce concentrations at any particular location, but the federal NAAQS would probably still be exceeded. At Tx-S, total PM_{10} emissions would be 78,411 lb/d and 1-hr ground-level PM_{10} concentrations would be 1,800 $\mu g/m^3$ at the site boundary and greater that 150 $\mu g/m^3$ about 2.9 mi downwind of the site.

The estimated PM_{10} emission rate would be 113,813 lb/d at the Rx-W, resulting in average 1-hr ground-level PM_{10} concentration of about 2,500 $\mu g/m^3$ at the downwind edge of the site. The PM_{10} concentration would drop to 150 $\mu g/m^3$, at a distance of about 5.5 mi from the site. At Rx-E, PM_{10} concentrations at the site boundary would be 2,100 $\mu g/m^3$ and would exceed 150 $\mu g/m^3$ up to 4 mi downwind of the site. Because PM_{10} particulates represent roughly one-half of TSP, a PM^{10} concentration of 150 mg/m^3 is comparable to the Minnesota 24-hr TSP standard of 260 $\mu g/m^3$. Again, wind shifts during the 24-hr period would disperse the particulates, reducing concentrations at particular locations.

Sensitive receptors which could be affected by PM_{10} levels consist of rural residences. Depending on the alternative site selected, 5-11 residences would be located within 2 mi of the transmit and receive sites (see Table 3.4.3). Because PM_{10} concentrations at the CRS construction

site itself and immediately downwind of it could exceed air quality standards, protection of on-site construction personnel could be necessary at certain times during site preparation. Mitigation measures to reduce fugitive emissions are discussed in Section 4.3.6.

Dispersion of CO and NO_x emitted by engine exhausts was also modeled. The resulting estimated concentration would not exceed applicable state and federal air quality standards. For example, the maximum 1-hr CO concentration would be 6.7 $\mu g/m^3$, about 1/6,000th of the federal 1-hr CO standard. Mitigation of vehicle emissions would not be necessary.

4.3.3 CRS Operation

During operation of the sites, criteria air pollutants would be emitted from staff vehicles being driven to and from the site and from occasional testing or emergency use of standby diesel-electric generators. The facility would be staffed in three daily shifts of 5-6 people. The emissions from the small number of staff vehicles and from limited use of emergency power generators would not result in significant air quality impacts.

4.3.4 Decommissioning

Dismantling and decommissioning of the site at the end of its operational life would generate pollutant emissions similar in kind to those generated during site construction, but for a more limited time and without the large fugitive dust emissions generated by the extensive earthmoving and grading activities involved in site preparation.

Pollutant sources would likely consist of exhaust emissions from truck traffic and vehicles of personnel engaged in removing superstructure and hauling equipment and materials from the site. Dismantling of structures and hence the emissions would take place over a limited period and would be subject to the laws and regulations in force at the time of decommissioning. Because the decommissioning process is not well defined and the standards that would regulate air quality impacts at the end of CRS operational life are not known, the air quality impacts of decommissioning cannot be determined at this time. However, because dust emissions that would

cause the most significant impact on air quality during CRS construction and would be much lower during decommissioning, the potential for significant effects would be low.

4.3.5 Powerline Construction

Air pollutants that would be generated during construction of powerlines for the transmit and receive sites include dust from construction activities and NO_X, HC, CO, and SO_X from vehicles. Dust could be generated from areas of soil disturbance, clearing of brush and tree debris, vehicle movement over bare earth, and undergrounding of the powerline at the receive site. However, the small areas involved indicate that relatively little dust would be generated, and would have insignificant air quality impacts.

Criteria pollutants from the construction and maintenance vehicle engines would be emitted at diverse, isolated places and times in rural environments having a windy climate and changeable weather conducive to dispersing these pollutants. Thus, such emissions would not result in significant air quality impacts.

4.3.6 Mitigation Measures

The only air quality impacts from the project requiring mitigation would be fugitive dust generated during site preparation. Implementation of measures M4.3.1, M4.3.12, M4.3.3 and M4.3.4 would be required to mitigate dust generation, which would be a significant impact even after application of the measures. Emissions generated during other phases of the project would not result in concentrations exceeding state or federal air quality standards. The following measures would apply at all of the alternate CRS transmit and receive sites.

M4.3.1 - To reduce fugitive dust emissions from vehicle travel over unpaved surfaces:

- Travel of construction equipment over dirt roads and other bare surfaces could be minimized, especially for on-site haul trucks
- Gravel could be placed on main traffic routes at the construction sites early in the site preparation process

- Exposed soil surfaces could be moistened daily with water, perhaps containing chemical dust suppressants or other surfactants.

M4.3.2 - To control dust generated by wind erosion of soil:

- Construction could be phased to minimize the amount of bare earth surfaces exposed at any one time
- Exposed surfaces that will not be further disturbed, but must wait before being covered by gravel or structures, could be treated with chemical dust suppressants designed to cement loose material
- Bare surfaces could be sprinkled with water, or water containing dust-suppressing additives, while they are being prepared for gravel emplacement, pouring of foundations, or other surfacing operations
- Exposed soil could be stabilized where possible, by planting vegetative ground cover.

M4.3.3 - To control dust from haul trucks, their loads could be wetted or covered.

M4.3.4 - To reduce the respiratory hazard of PM_{10} particulates, monitor PM_{10} concentration, and specify protective measures such as face masks or enclosed cabs.

M4.3.5 - To reduce dust emissions, use on-site borrow for fill wherever possible, thereby reducing the number of required haul truck trips. Locate borrow source as close as is feasible to the construct sites, minimizing the length of haul truck trips.

4.4 NOISE

4.4.1 CRS Construction

Construction activities will generate high noise levels intermittently on and adjacent to the sites. The activities will begin with clearing, grading, road construction, hauling, and earthmoving

operations required for site preparation. No blasting is anticipated at any of the sites. This phase will be followed by construction of building foundations, erection of metal buildings, erection of the antenna arrays, installation of lighting, laying of the groundscreen, and installation of system equipment. At both transmit and receive sites, the two phases will take place over approximately 17 months, from March 1991 to July 1992, for the initial two sectors. The sequence will then repeat over another 17 months during 1993 and 1994 for the remaining two sectors. On the basis of an average mix of industrial construction equipment, noise levels for different phases of construction, were estimated (see Table 4.4.1).

Table 4.4.1
TYPICAL INDUSTRIAL CONSTRUCTION NOISE LEVELS[a]

Construction Phase	Noise Level (dBA, Leq)[b]
Ground clearing	87
Excavation	89
Foundations	89
Erection	84
Finishing	84

Note: L_{eq} = energy equivalent noise level.

[a] Noise levels estimated for a distance of 50 ft from the construction activity.

[b] Based on typical mixes of construction equipment, taking into account average use factors.

Source: ESA, 1990; Bolt, Baranek, and Newman, 1971

Using an approximation of noise attenuation of 6 dBA per doubling of distance, typical of point noise source, the noise level at receptors of 0.5-1.0 mi from the construction sites would be about 57 dBA. At receptors 1-2 mi from the noise source the noise level would be approximately 50 dBA. The estimated noise levels are for daytime hours during weekdays. The EPA-recommended maximum noise level for residential land use is 55 dBA L_{dn} whereas the state of Minnesota has set limits of 60 dBA L_{50} and 65 dBA L_{10} for residential land use. Depending on the specific transmit and receive sites selected, 2-8 residences would be closer than about 1 mi from construction activities. Noise levels of these houses would be more than 5 dBA above the estimated existing rural noise level of 45 dBA L_{dn}. Consequently, the noise impact on residents of those houses would be significant and require mitigation. In addition, although back-up warning signals on construction vehicles are too sporadic affect average noise levels, they would be an intermittent and distinct source of noise that could irritate nearby residents. Mitigation measures to limit construction noise are in Section 4.4.5.

Truck traffic to and from the construction sites will also generate noise. Trucks carrying clean fill and gravel to the sites will make frequent trips during the 26 weeks of site preparation from up to 25 mi away from the transmit site and up to 10 mi from the receive site. Several hundred truck trips per day could be made at the transmit and the receive sites, primarily during the site-preparation period (July to December 1991 for the initial two sectors). In addition, as many as 220 construction workers will drive their own vehicles to and from the construction sites during the construction period. Although the traffic increase on surrounding roads would be large compared with existing traffic levels, the increase would be spread throughout a rural area, and rural residences subject to increased traffic noise are also scattered throughout the region. No significant impacts from project-generated traffic on level of service of local roads are anticipated at any of the sites. (Metcalf & Eddy/Holmes & Narver, 1990C) Individual trucks travelling at a speed of 50 mph would cause noise levels of 85 dBA at houses 50 ft from the roads for the few seconds it takes the truck to pass by. For houses 100 or 200 ft from the road, noise levels would be 81 dBA and 76 dBA, respectively. That noise would be too sporadic to significantly affect average noise

levels. However, the Minnesota L_{10} noise descriptor for household units would be exceeded at houses along the haul route. No similar standard exists for South Dakota.

4.4.2 CRS Operation

Both the transmit and receive sites will be staffed by about 25 persons, working in 8-hr shifts of up 5-6. A perimeter road outside the exclusion fences will be used for security patrols. The antenna arrays will would be stationary structures, and the equipment used to them will be electronic. Therefore, the noise from operation of the CRS sites will result primarily from vehicles used by security patrols and personnel traveling to and from the site for each work shift. That noise will be insignificant.

4.4.3 Powerline Construction and Operation

The CRS will require construction of two 115-kV powerlines with wooden "H-frame" or steel monopole structures along a ROW up to 150 ft wide. A substation will also be constructed. Construction activities will consist of preparing the sites for the support frames, assembling and erecting of the frames, and mounting the conductor wires. The noise from these construction activities will be similar to the noise levels listed in Table 4.4.1. Because construction activities at the location of each transmission structure will be brief, noise impacts would be insignificant.

The transmission line may generate corona-discharge. This cracking, hissing sound intensifies during wet weather, but even then, would be less than 19 dBA at the edge of the ROW.

Noise will also be generated at the transmit-site substation by the transformers (a "hum") and by exposed conductors (corona discharge). Noise from both sources would not exceed standards established by National Electrical Manufacturing Association and would be attenuated to background levels within a few hundred ft of the substation.

The transmission line for the receive site will be either mounted on single wooden poles or placed underground. Construction noise would be generated at levels similar to those given in Table 4.4.1. Because of the short construction time and the general absence of sensitive receptors

(the route traverses primarily rural country), the noise impact would be insignificant. Powerlines to the receive facilities will generate less transmission-line noise than the transmit-site powerlines because they will operate at much lower voltage.

4.4.4 Decommissioning

Dismantling and decommissioning of the CRS sites at the end of its operational life likely would consist, at a minimum, of removing the structures and hauling equipment and materials from the site. This could generate noise similar in intensity to that generated by construction, but for a shorter period of time and without the noise associated with earthmoving and grading during site preparation. Thus, noise during this period would be insignificant.

4.4.5 Mitigation Measures

The project is planned for sites in sparsely populated rural areas. Construction noise and project-generated traffic noise would generally be attenuated to acceptable levels before reaching most receptors. However, residences close to the construction activities or near routes used by heavy trucks or other project vehicles would be significantly affected. The following measures are required to mitigate construction noise:

M4.4.1—Muffle and shield intakes and exhaust, shroud or shield impact tools, and use electric-powered rather than diesel-powered construction equipment, as feasible.

M4.4.2—Limit the hours of construction from 7:00 a.m. to 7:00 p.m., and require the construction contractor to schedule trucks to arrive on site no earlier than 7:00 a.m.

M4.4.3—Choose traffic routes to and from the site, especially routes for heavy trucks, to minimize traffic noise impacts on farmhouses and other sensitive receptors.

4.5 ELECTROMAGNETIC INTERFERENCE

This section, based on Technical Report: Analysis of the Potential for Electromagnetic Interference and Radiofrequency and Powerline Field Bioeffects, Central Radar System, Over-the-Horizon Backscatter Radar Program, prepared by SRI International (1990), presents an analysis of the potential effects on other systems from operation of CRS transmitters at either of the two alternative transmit sites in South Dakota. The systems analyzed include those that use the electromagnetic spectrum, as well as others that are not designed to use it but that may be susceptible to the energy radiated by the radar. Systems in the first group include telecommunication and radio navigation systems, all of which are designed to sense electromagnetic energy. Systems in the second group include cardiac pacemakers and electroexplosive devices (EEDs) that may be sensitive to the radar energy. The potential for power lines, electrical motors, and arc welders to degrade performance of the CRS receive facilities is also analyzed.

4.5.1 Transmit Site

4.5.1.1 Overview

The likelihood that CRS will cause electromagnetic interference (EMI) to some other system depends on the operating characteristics of both systems and the amount of electromagnetic energy propagated from one to the other. The threshold of susceptibility for affected systems depends not only on the power density of the undesired signal at the potentially susceptible system (and therefore on the distance between them), but also on the frequency of the undesired signal and the characteristics of its modulation.

4.5.1.2 The OTH-B Signal

The most common OTH-B waveform is a linear frequency-modulated/continuous-wave (FM/CW) waveform. Table 4.5.1 lists key OTH-B parameters. Three parameters—center

frequency, period, and operating bandwidth—vary according to the needs of the radar system. The center frequency is selectable in 1-hertz (Hz) increments within the 5- to 28-megahertz (MHz) band; the signal sweeps within a selected operating bandwidth about that center frequency. OTH-B modulation is designed to minimize the transmitted power that falls outside the operating bandwidth.

Table 4.5.1
PARAMETERS OF THE OTH-B RADAR SYSTEM
(Per 60° Sector)

System Characteristics	Value
Continuous wave power	
Maximum [megawatts (MW)]	1.2
Minimum (kW)	37
Antenna gain, mainlobe maximum	
Ratio	160
Decibels	22
Antenna gain, sidelobe maximum	
Ratio	8
Decibels	9
Antenna gain, backlobe maximum	
Ratio	1.6
Decibels	2
Half-power beam width	8.4°
Dwell time, each azimuth, maximum (s)	10
Revisit time, maximum (s)	80

[a] All gain figures are stated relative to an isotropic distribution (uniform in all directions) and represent an average value over the operating frequency band.

[b] The term "sidelobe" is used here to refer to any radiation in front of the backscreen other than the mainlobe, whereas "backlobe" denotes any radiation behind the backscreen.

Source: U.S. Air Force.

The OTH-B radar does not generally scan the eight adjacent 7.5°- sectors of an array in any regular sequence. To counter any advantage that an adversary might gain from a predictable scanning pattern, the radar illuminates the sectors in an apparently random order. Each 7.5°- sector is revisited within 15-60 s, for an average dwell time of 2-8 s. The OTH-B radar radiates at 5-28 MHz, but also at frequencies that are integer multiples of the operating, or fundamental, frequency; these frequencies, called harmonics, are at least 10,000,000 times (70 dB) weaker than the fundamental signal (see Table 4.5.2). In addition, the transmitter system generates noise and spurious signals that are amplified and radiated by the transmit antenna. Random noise and spurious output signals from the transmitters are generally one billion times (90 dB) weaker than the fundamental signal.

Table 4.5.2
HARMONIC FREQUENCY BANDS OF THE OTH-B RADAR

Harmonic	Frequency Band (MHz)
Fundamental	5 to 28
2nd	10 to 56
3rd	15 to 84
4th	20 to 112
5th	25 to 140
6th	30 to 168
7th	35 to 196
8th	40 to 224

Source: SRI International.

The OTH-B radar does not constantly operate at full 1.2-MW power. When an adequate signal-to-noise ratio can be achieved with a lower output power, the radar's power level is reduced in steps of about 1 dB. The maximum available power reduction is about 15 dB, a factor of about 32; thus, the radar might sometimes operate using as little as 37 kW.

OTH-B signals propagate in two different forms: sky waves and ground waves. The target region and other regions can be illuminated by sky-wave signals. Depending on the condition of the ionosphere at subsequent potential reflection regions, the sky-wave signal makes one or more hops. Further, the radar's backlobes, which are weaker than the main beam by at least 20 dB (a factor of 100), can propagate by sky wave to regions behind the radar that are approximately the same distance away as the targets. In addition to frequencies at and adjacent to the fundamental, some harmonics and spurious signals below about 30 MHz can propagate by sky wave. Frequencies above 30 MHz do not propagate to distant regions. Some of the energy radiated by the OTH-B remains near the earth's surface, where it propagates by ground wave and is attenuated with distance much more rapidly than the sky wave.

An oblique-incidence sounder consisting of a swept-frequency transmitter and a broadband antenna will be associated with each CRS transmit sector. The sounder frequency will be swept continuously from 2-30 MHz at a rate of 100 kilohertz per second (kHz/s). Sounder transmissions will be locked out when the sweep generator passes through excluded frequencies. The functions of the sounder are to probe the path to and from the target area and to provide data to help choose the best frequency for the radar transmitter. The power radiated by the sounder will be 10 kW, and the gain of the sounder antenna would be less than that of the main antennas. Therefore, sounders will make a negligible contribution to the total radio frequency radiation (RFR) and are not given further consideration in this analysis.

The Air Force will use standard, commercially available, very high-frequency (VHF) or ultrahigh frequency (UHF) land-mobile radio systems at both the transmit and receive sites to support maintenance and security activities. These vehicle-mounted or hand-carried systems will operate on frequencies assigned by the National Telecommunications and Information Administration (NTIA) through the Interdepartment Radio Advisory Committee and will not interfere with other users of the land-mobile bands.

Operational data and instructions for controlling the system will be transmitted in real time between and among the CRS transmit and receive sites and the operations center. The radio system that will be used for this purpose will operate at power levels that are very low compared with those of the main transmitters. It is not analyzed further in this EIS.

4.5.1.3 Potential for EMI

Natural and Man-made Noise—The limiting distance at which the OTH-B ground-wave signal can be received, provided that no other signals are in that frequency band, is determined by the radio noise level in that same band at the receive site. If the power of the radio noise exceeds that of the OTH-B signal, the OTH-B signal will not be noticeable. If the receiver is tuned to a non-OTH signal, the OTH-B signal must exceed the combined power of the noise and the desired signal to be noticeable.

In the high-frequency (HF) band, the predominant noise usually originates from natural or man-made sources and enters the receiving system through the antenna. The most important source of naturally occurring noise at frequencies up to about 20 MHz is thunderstorms; radio noise from lightning propagates by sky wave, so that major storm centers influence the noise on a global basis. Above about 20 MHz, atmospheric noise decreases quite rapidly with increasing frequency. Man-made radio noise is the predominant noise at some frequencies in some areas—particularly in regions of high population density or heavy vehicle traffic. The major sources of man-made radio noise include high-voltage power transmission and distribution lines, automobile ignition systems, electrical motors, and fluorescent lights. Man-made noise, even in rural areas, is the limiting factor in the reception of weak signals.

CRS will be authorized to operate within any of about 20 blocks of the radio spectrum between 5 MHz and 28 MHz, which are also used by stations of the Fixed Service or the Broadcasting Service. Occupied channels will be avoided both to prevent interference to others and to prevent others from interfering with the radar's operation.

A version of the OTH-B system, termed the Experimental Radar System (ERS), was built and operated in 1981 in Maine to test and evaluate many of the radar's operational concepts and to investigate potential interference. The ERS operated only at frequencies between 6.74 MHz and 22.25 MHz, with a typical output power level of about 720 kW. Although intermittent operation of the ERS for more than a year produced several complaints of interference, only one actually corresponded in time and frequency with an ERS transmission. The single possibly valid complaint was logged by a Military Affiliate Radio System (MARS) station in Florida, which is a fixed station that uses 20.9375 MHz on a "limited schedule basis."

During ERS operation, the Air Force usually had to change its operating frequency several times during an 8-hr shift to avoid interfering signals. Clear 10-kHz channels for routine surveillance were always available, except for a brief time in winter, when only 5-kHz channels could be found. To minimize the risk of interfering with a legitimate user, the radar will use one of the Field Service Bands whenever possible.

The probability of interference to radio reception by the radar's ground-wave signal is slight. The ground wave will attenuate with distance to levels below the ambient noise. It will be undetectable at distances beyond about 100 mi and very weak at shorter distances; thus, only HF listeners within a limited range could possibly detect the ground-wave signal. An HF listener within the range of the ground-wave signal and receiving a sky-wave signal from some distant transmitting station could theoretically experience interference; but the sky-wave signal would probably be received by CRS, which would then reject that frequency for operational use.

The probability of interference by the radar's sky-wave signal will be higher, and such interference could occur in all directions at locations one or more ionospheric hops distant from the transmitter. Interference could occur if a distant transmitter were propagating a signal to various parts of the world that, because of ionospheric propagation conditions, did not include the CRS site. Thus, if an HF transmitter were about 100 mi away, neither its ground wave nor its sky wave would reach the radar. In that situation, although the radar system would monitor the spectrum

before transmitting, the monitoring would indicate that the in-use channel was clear. Such interference would not necessarily be constant. Each of the radar's four arrays will switch its beam to sequentially illuminate its eight 7.5°- barrier sectors, and the same or different frequencies may be used. If the same frequency were in use, the interference would occur only for the roughly one-eighth of the time when the radar's beam is directed appropriately.

Fixed Point Communications Links—The U.S. Army Corps of Engineers operates about 20 fixed point-to-point communication links with power levels of 100 W at frequencies between 5.298 and 6.022 MHz near the proposed CRS transmit sites. The Federal Communications Commission (FCC) authorizes about 40 other stations of various classes in this geographic region to transmit at frequencies between 5 MHz and 28 MHz. Because those stations do not broadcast continuously, the CRS and will avoid mutual interference by using unoccupied frequencies.

Amateur Radio—The Amateur Radio Service occupies several bands within or adjacent to frequency band used by the OTH-B radar. Except for the 40-m band, these bands are set aside worldwide for the exclusive use of the amateurs. (The 40-m band is used by amateurs only in North and South America; in the rest of the world, this band is allocated to broadcasting.) CRS will operate in bands adjacent to the amateur bands and enough of the radar's energy could fall into an amateur band to produce interference to the users there.

An article describing the ERS and the interference effects that might occur was published in the amateur radio magazine QSP at about the time that the ERS began testing. The article urged the amateurs to submit reports of any interference to the OTH-B Program Office. No reports of ERS-produced interference in the amateur bands were received, indicating that the potential for CRS interference with amateur radio use is very low. The CRS would not create interference like the Russian radar informally known as the "woodpecker" because the CRS will have a continuous wave signal while the Russian radar has a pulsed signal. Additionally, the CRS will transmit at much lower power levels than the woodpecker.

Television—Fundamental overload can occur (usually only on VHF TV channels) if the fundamental OTH-B signal is strong enough at the Television's antenna terminals to overload the TV tuner's input circuitry. Most modern TV receivers are equipped with a simple high-pass filter in the antenna input circuit to provide a moderate degree of overload protection from signals at frequencies below the Television broadcast band. In extreme cases when the internal filter is inadequate, an external filter can be installed in the antenna lead to provide additional protection. Antenna-mounted preamplifiers, sometimes used for improved reception in low-signal-level areas, can also susceptible to fundamental overload. However, installation of a high-pass filter between the antenna and the preamplifier eliminates that problem.

High-power interference effects occur when a receiver is sufficiently close to the OTH-B transmit site for the RF energy to couple either directly into the receiver circuits or through the powerline to produce interference. High-power effects can occur only at televisions within a few miles of the radar.

The OTH-B radar does not affect direct satellite television receiving systems because of the directionality of the receive antennas and the great separation between the satellite and radar frequencies.

The radar's harmonic or spurious emissions can interfere with either direct-broadcast television signals or any translators' signals. Because harmonic interference depends on specific relationships between the television and radar frequencies, the interference would be intermittent. The radar would have to be transmitting on the appropriate subharmonic of the television signal. As an example, the picture carrier of a Channel-3 signal, such as that from KDLO (Garden City, South Dakota), is at about 61.25 MHz. For third-harmonic interference, the radar would have to be using a frequency very close to 20.42 MHz. Even if the frequency relationships indicate potential interference, the actual occurrence of interference from the harmonics or spurious signals would depend on a number of factors, including (1) the strength of the radar's emissions in the television channel; (2) the strength of the television signal at the viewer's location; (3) the

directional characteristics and orientation of the television receiving antenna relative to the CRS site; and (4) the distance and terrain characteristics between the CRS transmitter site and the television receiving location. Television interference will probably not be experienced more than about 5 mi from the CRS transmitters.

Measures can be taken to prevent television interference. If certain harmonics of the OTH-B signal produce interference with reception, it would be possible to restrict the radar from using the particular frequency that interferes. Other forms of interference could be corrected using appropriate filters.

Land-Mobile Radio—The MITRE Corporation made measurements to estimate whether ERS harmonics could interfere with low-band VHF (roughly 30-50 MHz) mobile radio. While ERS was operating, measurements were made on 10 frequencies between about 32 MHz and 57 MHz that corresponded to second, third, fourth, or fifth harmonics of the ERS-transmitted frequencies. (Abel, 1981) MITRE performed the measurements at distances of 1, 2, and 3 mi from the ERS. At 1 mi, ERS harmonic signals were found on 5 of the 10 frequencies; on the other 5 frequencies, the ERS harmonics were below the ambient noise level and therefore too weak to be detected. At 2 mi, only three of the ERS harmonics were greater than the ambient noise level. At 3 mi, none of the harmonics was evident above the ambient noise level. (Abel, 1981)

The measurements suggest that the chance of harmonic interference in the low VHF land-mobile band is about 50% if the receiver is receiving a very weak signal and is within 1 mi of the OTH-B transmit site. At 2 mi the likelihood falls to about 30%, and at 3 mi the potential for interference is very low.

AM and FM Radio—AM and FM radio broadcasts were monitored on an automobile radio at a number of locations along the ERS transmitter access road and along other roads near the transmit site while the ERS was operating. The ERS produced no interference in either the AM or FM broadcast bands at distances greater than about 1 mi from the ERS transmit antenna. (Abel, 1981)

The maximum CRS output power will be somewhat greater than that used during ERS testing. Furthermore, because the ground conductivity near the CRS transmit site may be higher than in Maine, ground-wave propagation may be somewhat better. Consequently, CRS operation could interfere with broadcast radio reception within 2 mi of the transmit site.

Airborne Communication and Air Navigation Systems—Because some aeronautical mobile bands are adjacent to the bands used by the OTH-B radar, aircraft flying at sea could be illuminated from above by a radar signal close to the aircraft's communication frequency. Abel (1980b) studied this possibility to determine the amount of frequency separation (guardband) necessary to prevent the ERS from producing adjacent channel interference. He found that 16-kHz guardbands would sometimes be needed although narrower guardbands would often be adequate. The results depend on the radar's power level and on ionospheric propagation conditions, both of which will be different for CRS.

The VHF air-mobile communication frequencies in the 118-132-MHz band could be susceptible to fifth harmonics of the radar when it transmits on frequencies in the 23.6-26.4-MHz range and to sixth harmonics when it transmits between 19.67 MHz and 22.0 MHz. Abel (1981) calculated that the ERS would not interfere with airborne VHF receivers at distances beyond about 16 mi. The CRS will have about 15% more power than the ERS had during testing. Thus, although the potential for CRS to interfere with airborne VHF communications is somewhat greater, ERS experience suggests that such interference will not be a problem.

Radio-operated aids to air navigation consist of aircraft and equipment aircraft and ground stations maintained throughout the United States by the FAA. Aircraft routinely obtain bearing information from VHF omnirange (VOR) transmitting stations operating in one of about 100 channels in the 108-118-MHz band. Distance-measuring equipment (DME) enables an aircraft to determine its distance from the ground-based DME station, using channels in the 960-1,215-MHz band (see Table 4.5.3). VOR and DME stations are collocated so that an aircraft can determine both its distance and direction from the station, which is then referred to as a VOR/DME. When a

VOR is collocated with a military distance-measuring system, called TACAN (for Tactical Air Navigation System) the combined facility, from which either a civil or a military aircraft can determine both its distance and direction, is called a VORTAC. Like DME, the TACAN portion of the VORTAC operates in the 960-1,215-MHz band. Three VOR/DME and four VORTAC stations are located within about 120 mi of the CRS transmit study area. Under ideal conditions, a VOR can be used at distances up to about 130 nmi (150 mi) by an aircraft at 18,000 ft and at greater distances if the aircraft is at higher altitudes.

Table 4.5.3
VOR STATIONS AND NONDIRECTIONAL BEACONS WITHIN ABOUT 120 MILES OF ALTERNATIVE CRS TRANSMIT SITES

Call Letters	Location	Miles from Transmit Sites	Channel	Operating Frequency (MHz)	Subharmonics (MHz)	
					Fifth	Sixth
VORTACs						
ABR	Aberdeen	34	Ch 77	113.0	22.60	18.83
ATY	Watertown	70	Ch 113	116.6	23.32	19.43
FAR	Fargo	96	Ch 109	116.2	23.24	19.37
HON	Huron	96	Ch 123	117.6	23.52	19.60
VOR/DMEs						
MVE	Montevideo	120	Ch 53	111.6	22.32	18.60
MOX	Morris	100	Ch 33	109.6	21.92	18.27
FFM	Fergus Falls	100	Ch 41	110.4	22.08	18.40
Nondirectional beacons (NDBs) and their frequencies						
BTN	Britton	10	386 kHz			
GWR	Gwinner	30	278 kHz			
ETH	Wheaton	70	326 kHz			
BWP	Wahpeton	73	233 kHz			
VVV	Ortonville	78	332 kHz			
BBB	Benson	120	239 kHz			
DXX	Dawson-Madison	100	227 kHz			

Source: U.S. Department of Commerce, 1986.

The OTH-B radar can inter with an aircraft's VOR receiver by causing false bearings if the radar is transmitting on or near subharmonics of the VOR frequency. Abel (1981) described two investigative measurement flight sequences. In the first, an aircraft was flown along radials from the ERS site toward each of several VORs while the ERS transmitted on various permitted frequencies ranging from the sixth to the tenth subharmonics of the VORs involved. The ERS caused oscillations of the indicating needle greater than ±2° (or other false bearing readings) at distances of up to 24 mi from the ERS transmit site.

The FAA also conducted measurements, using its own instrumented aircraft. It flew three 360° orbits around the ERS at a range of about 17 mi and an altitude of 5,000 ft while the ERS was transmitting on frequencies as far as 8 kHz below the sixth subharmonic of a VOR about 45 mi away. Out-of-tolerance course errors (greater than 3°) occurred at a number of azimuths, generally in front of the radar. In another flight, the FAA followed a route directly away from a VOR about 60 mi from the ERS, approaching the ERS from behind and passing within about 6 mi of it. The ERS was transmitting on a frequency 1.67 kHz below the sixth subharmonic of the VOR. Course errors were less than 1° until the aircraft was about 8 mi behind the ERS. Course errors then became greater than 3° until the aircraft passed into the region in front of the radar; there the errors became so large that the VOR signal was unusable at distances out to about 26 mi. On the third flight, the FAA approached within about 25 mi of and essentially in front of the ERS while the ERS was transmitting on the sixth subharmonic of the VOR in use. No interference was noted in that case.

According to ERS experience, the CRS could produce interference if it transmitted on or very near the sixth subharmonic of a local VOR frequency. The region in which this interference may occur extends about 26 mi in front of the transmitting antenna to about 10 mi behind it. In the case of the CRS, having four arrays, the possible sixth-subharmonic interference region "in front of" the radar would be a 240° arc centered approximately due south and having a radius of about 26 mi;

the corresponding region "behind" the radar would be a 120° arc centered approximately due north and having a radius of about 10 mi.

Because the CRS radar transmitter would use the 22.25-28.00 MHz band in addition to those used by the ERS, interference could also occur when the radar transmits on a VOR's fifth subharmonic. To prevent that, the Air Force could include both the fifth and sixth subharmonics of the nearby VORs in the list of forbidden transmit frequencies.

A number of airports in the area are served by NDBs that omnidirectionally broadcast a coded identifying signal on a frequency in the 200-1,600-kHz band. Aircraft carry a direction-finding system by which that can determine the direction from the plane to the beacon. The effects of the CRS signal would be similar to those experienced when a plane using an NDB signal passes close to any large HF transmitter, such as those used by Voice of America and other users of the International Broadcast band.

4.5.1.4 Hazard Effects

This section analyzes the potential for CRS electromagnetic fields to affect implanted cardiac pacemakers, EEDs, fuel ignition, and power lines. The findings of these analyses are discussed below.

Implanted Cardiac Pacemakers—The heart can be regarded as an electrically operated pump. It is a set of muscles that contract rhythmically in response to a periodic electrical impulse that originates naturally in the cardiac tissue. Some people who suffer impaired operation of the natural pacemaker or of the conducting paths in the cardiac tissue rely on an artificial pacemaker to supply the electrical signal to make the heart beat properly. Hundreds of thousands of people in the United States have pacemakers. Four general types of cardiac pacemakers are used, but 80-90% of the pacemakers in use are of the R-wave-inhibited type. The R-wave-inhibited pacemaker senses the naturally occurring electrical signal of the main pumping action of the heart. If that fails to occur, the pacemaker supplies the signal to trigger the heart's action.

Pacemakers do not fail permanently when exposed to strong RF fields; instead, if the field is sufficiently intense, they may exhibit one of four types of dysfunction, the most common of which (for a demand pacemaker) is termed "reversion." This means that the pacemaker reverts to a benign fixed rate that is not harmful. In fact, to monitor the pacemaker's battery condition, a pacemaker owner frequently will deliberately cause his pacemaker to assume that condition.

The modulation of the RF field largely dictates whether and how a field will affect a pacemaker. Pulse modulation is the form of modulation most likely to affect a pacemaker, because the pacemaker is designed to sense electrical pulses. According to Denny et al. (1977), an R-wave-inhibited pacemaker is likely to misinterpret modulations below 10 pulses per second (pps) as the electrical activity of the heart and to become inhibited (stop producing pulses). At higher pulse rates, the pacemaker is more likely to revert to a synchronous operation. Long-term inhibition (greater than about five normal heartbeats) may be hazardous for some owners, whereas reversion to fixed-rate pacing is less serious.

The Association for the Advancement of Medical Instrumentation (AAMI) drafted pacemaker susceptibility standard in 1975 (AAMI, 1975). In accordance with that draft standard, the pacemakers now being marketed are capable of unaffected operation in 450-MHz pulsed field strengths exceeding 200 V/m. (That implies that they would also almost certainly be capable of unaffected operation in a frequency-modulated field of 200 V/m.) The 1975 draft standard also required that the pacemaker be unaffected by CW (unmodulated) power-frequency signals directly coupled to the pacer at a 100-mV level. A later (November 1981) draft version of the AAMI pacemaker standard describes various performance tests, but all references to EMI susceptibility testing have been dropped. According to a cochairman of the AAMI pacemaker committee (Flink, 1982), one reason this was done was to make the U.S. standard more similar to an international standard so as to facilitate trade. The other reason was that the committee believed that a rigid electromagnetic compatibility standard could encourage manufacturers to produce pacemakers with EMI susceptibility no better than the minimum requirements of the standard. Flink also stated that modern pacemakers are almost invulnerable to EMI.

Susceptibility levels of pacemakers, based on pulsed 450-MHz tests in August 1975, were published by Mitchell and Hurt (1976). That report states that the susceptibility levels (ranging from 4 V/m to more than 260 V/m) "are believed most representative of the current state of technology" (for 1975). The report also states that "if pacemakers were designed and tested to be compatible with the minimum E-field level (about 200 V/m) associated with the unrestricted 10 milliwatt per square centimeter (mW/cm^2) personnel exposure level, potential EMI situations would be substantially reduced or effectively eliminated." Such a 200-V/m testing level, described in the 1975 standard prepared by the AAMI for the U.S. Food and Drug Administration (FDA), is now in general use.

The only known measurements that indicate the susceptibility of pacemakers to RF fields in the HF band were conducted by the Air Force in 1977. (Hardy, 1979) In addition to pulsed signals at other frequencies, Hardy worked with a CW signal at 26 MHz, which is similar to the CRS signal. Hardy reported that 17 of 30 pacemakers were unaffected by fields as high as 850 V/m—the maximum field available from the test system. The susceptibility thresholds of the other pacemakers ranged from 230 V/m to 850 V/m.

Both Mitchell (1978) and Denny (1978) suggest that the pacemaker manufacturers were then probably meeting the 200-V/m level in their newer models. The 1977 measurements reported by Hardy in 1979 indicated that many were not susceptible to 450-MHz pulsed signals with levels as high as 330 V/m. Denny stated in 1978 that the threshold for most of the newly released pacemakers was above 300 V/m.

By 1993, when CRS testing will begin, the pacemakers described in the literature of 15 years earlier would probably not be in use. Because an entirely new pacemaker must be implanted when the battery becomes exhausted, and the new pacemaker will likely be less susceptible to EMI. Thus, the susceptibility thresholds of the pacemakers that would be exposed to CRS transmissions would be quite high.

As noted above, pacemakers are not very susceptible to HF signals. Because the CRS signal is essentially continuous (and not pulsed), the pacemaker would not confuse it with the naturally occurring electrical signals that the pacemaker is designed to sense. Available data suggest that modern pacemakers would be affected by the CRS only if the field strengths were well over 200 V/m. At ground level in front of the CRS antennas, fields will fall below 200 V/m at a distance of about 1,300 ft from the center of the array. Fields of 200 V/m would not exist at all behind the CRS antennas. Because the exclusion fence would be located about 4,000 ft in front of each array, a pacemaker owner approaching the radar outside the exclusion area would not be subjected to fields exceeding 30 V/m; thus, CRS will present no hazard to pacemaker owners.

In the sky in front of the radar, on the axis of the main beam, the fields will fall below 200 V/m at a slant range of about 1,300 ft. The main beam axis at this distance would be about 400 ft agl and just over 1,100 ft horizontally from the array, which is well within the area enclosed by the exclusion fence. It would be highly unlikely for a pacemaker owner to fly into this small region of airspace.

Although CRS operation is unlikely to pose a hazard to pacemaker owners, the Air Force will request that the FAA publish a Notice to Airmen (NOTAM) warning fliers not to approach the radar too closely. Such NOTAMs have been published for other Air Force radars. The air space 5 nmi in front of the transmit site will be permanently restricted to an elevation of 5,000 ft agl.

Fuel Handling—The military has long been concerned about the possibility that high-power radars could ignite volatile fuels as they are transferred. Ignition would result if the high RF fields caused a spark across a gap in a fuel-air mixture of certain proportions. Researchers have determined the amount of direct current (dc) spark energy required to ignite fuel. According to Air Force Technical Manual T.O. 31Z-10-4 (1971), "The amount of RF voltage required to break down a similar gap is unknown but is believed, until proven otherwise, to be approximately the same as the dc-voltage value." For fuel handling near a radar, "a peak power density of 5 W/cm^2 (5,000 mW/cm^2) or less can be considered safe."

For CRS, which will operate continuously, the peak power density and the average power density are synonymous, and in the near field will not exceed about 1,109 mW/cm^2, which is considerably lower than the maximum safe power density of 5,000 mW/cm^2. Thus, the CRS radar system will not pose a hazard to fuel-handling operations.

Electroexplosive Devices (EEDs)—EEDs are used to activate secondary explosive charges, to ignite propellant systems, and to actuate electroexplosive switches. A common electric blasting cap is one form of EED. EEDs are used in aircraft systems to jettison flares, to release externally carried missiles, and, in some aircraft, to activate ejection seats. All EEDs are ignited electrically and hence are vulnerable to accidental ignition by exposure to electromagnetic fields. The degree of susceptibility depends on many variables: the safe no-fire threshold of the EED, the ability of the EED leads to capture RF energy, the frequency and power density of the RF energy, and the exposure condition of the EED—whether contained in a shielded cannister, mounted inside an aircraft with shielding provided by the skin of the aircraft, or exposed to the environment with no shielding present.

The potential hazard to EEDs such as blasting caps is concisely stated in the following quotation:

> From a practical standpoint, the possibility of a premature explosion due to RF energy is extremely remote. This has been demonstrated by numerous tests on representative transmitting equipment, and it is confirmed by many years of experience. The annual consumption of electric blasting caps is well over 100 million, and they are used in every section of the country. Yet there have been only two authenticated cases of a cap being accidentally fired by radio. Both these were caused by amplitude-modulated (AM) transmitters operating in the low frequency range (540-1600 kilocycles) with horizontal antennas (State of Maine, 1976).

The Air Force criterion for safe exposure of EEDs to RFR is expressed either as a safe average power density (in W/m^2), or as a safe separation distance. The safe separation distances specified by the 1988 update of AF Regulation AF 127-100, Explosive Safety Standards (U.S. Air Force, 1983) are based on a worst-case situation—that is, on the most sensitive EED currently in inventory, unshielded, and having leads or circuitry that could inadvertently be formed into a resonant antenna. The actual firing threshold of the EED may be several orders of magnitude above the safe no-fire threshold.

Table 4.5.4 summarizes the AF Regulation 127-100 criteria for safe power flux density exposure for EEDs in several configurations. All safe exposure limits are given in terms of average power density in the 2-48.5-MHz frequency range.

Table 4.5.4
LIMITS FOR SAFE EXPOSURE OF EEDs TO CRS FREQUENCIES

	Maximum Power Density	
Exposure or Storage Condition for EED	W/m^2	mW/cm^2
EEDs in storage or transport, in metal containers, leads shorted	100	10
Aircraft in flight with externally loaded weapons, or shipment of EEDs inside cargo aircraft	100	10
Aircraft parked or taxiing with externally loaded weapons	1.0	0.1
EEDs in storage or transport, in nonmetallic containers, leads shorted	0.1	0.01
EEDs in exposed condition (also applies for any "unknown worst case" situation)	0.01	0.001
Leadless EEDs in original shipping configuration	(No maximum power density; minimum distance 10 ft)	

Source: USAF, 1983.

Based on power densities that the CRS will generate, EEDs stored or being transported in metal containers at ground level would be safe at distances beyond about 1,500 ft from the CRS antenna. Aircraft in flight with EEDs would be safe at a slant range of more than about 1,500 ft in front of the radar. The NOTAM for CRS will warn fliers against approaching the radar.

EEDs stored or being transported at ground level in nonmetal containers would be safe at distances greater than roughly 6 mi from the front of the radar and about 3,000 ft behind it. Exposed EEDs, such as blasting caps being handled in preparation for a blasting operation, would be safe if removed to about 7 mi.

The use and handling of electric blasting caps are specifically addressed in a publication by the Institute of Makers of Explosives (1981). The publication recommends safe distances from common emitters of RFR rather than safe exposure limits in terms of power densities. The evaluation that most closely approximates the OTH-B situation is a curve of "recommended distances from transmitters up to 30 MHz [excluding amplitude modulation (AM) broadcast]" and applicable to "International Broadcast Transmitters in the 10-25 MHz range." The curve shows the safe distance as a function of the power that the transmitter puts into the antenna. For CRS, that power is 1.2 megawatts (MW), and the safe region would begin at about 19 mi. The Air Force will notify affected land owners and state and local government offices so that they can take any actions, such as making notifications or posting, that they deem appropriate.

Powerlines—The CRS transmit sectors require two 115-kV power lines to supply electricity. The amount of RFR from CRS absorbed by the powerlines will be very small compared to the 60-Hz load carried by the lines. Therefore, possible CRS effects are limited to interference with carrier-control circuits used for switching and monitoring of transmission lines. The interference potential could be eliminated by using carrier frequencies below 5 MH.

Aerial power lines in front of the CRS transmit antennas could affect the radiated beam if located sufficiently close to the antennas. The distance at which the sky wave separates from the ground wave increases with decreasing frequency and has a maximum value of 11,980 ft for Band

A. At that distance, the beam is 200 ft agl. Thus, no effect on the CRS beam would result from power lines greater than 11,980 ft from the antenna face. Power lines located behind the antennas would not cause any effects.

4.5.2 Receive Facilities

CRS performance could be impaired if the receiving antennas were subjected to excessive radio noise. Potential sources of radio noise analyzed here are power lines, electric motors, and arc welding machines. Relatively weak noise sources could be significant because the receiving site is remote from most sources of man-made noise. Significant interference potential could affect siting of CRS or require restrictions on nearby public activities.

4.5.2.1 Powerline Effects

Powerlines could generate RF noise by several different mechanisms. In very high-voltage lines, the dominant effect would be corona, in which air near the lines is partially ionized by the intense electric fields. Another noise-producing mechanism is the passage of irregular leakage currents allowed by dirty insulators. Still another source of radio noise could result from imperfect contact between the numerous metal parts that make up transmission lines. If parts that should be firmly bonded become separated by vibration and corrosion, electric current could pass between them in the form of small arcs, generating both acoustic and radio noise. This phenomenon would not be limited to the parts intended to carry current; metal braces that support crossarms or insulators could also cause noise-generating arcs.

All of these effects are more pronounced in high-voltage, high-power lines than in those operating at lower voltages and currents. If adverse effects from nearby power lines were to affect the CRS receive site, that problem could be mitigated. Corona interference could be reduced or eliminated by placing the powerlines underground. Effects from dirty insulators and imperfect metal contacts can be reduced by proper maintenance.

4.5.2.2 Electrical Motors

Electric motors that operate from single-phase alternating current rarely generate electric noise except during brief starting intervals. Three-phase motors are essentially noise-free. The motors most likely to interfere with the CRS are dc commutator motors that are often used for pumping irrigation water. Interference of this kind could be eliminated or sharply reduced by proper maintenance of the brushes and commutators.

4.5.2.3 Arc Welding

Arc welding machines come in a variety of types and sizes. The principal distinctions are dc versus ac devices, and with or without RF auxiliaries to start and maintain the arc. Some dc welders use motor-generator sets that are subject to brush and commutator noise from the electric motors, as mentioned in the preceding section. In welding machines, the most probable source of RF noise is the built-in RF generator that serves to initiate and stabilize the welding arc. Machines of this kind are more expensive than those without the RF subsystem and are therefore more likely to be found in a professional welding shop than in a private house or a farm.

The RF subsystems used in arc welders are subject to a power constraint imposed by the FCC that limits the radiated field strength at a distance of 1 mi to 10 μv/m. Unfortunately, that would be about 120 dB stronger than other noise levels likely to be present at the CRS receive site. Considering surface wave propagation and earth curvature, such a source could be detectable at distances up to about 100 mi. However, significant interference with CRS operations would result from arc welding within 1.5 mi of the receive antennas. The Air Force may request advance notice for arc welding planned within that 1.5 mile zone.

4.5.3 Power Supply

The powerlines constructed to supply electricity to the CRS transmit and receive sites will generate 60-Hz electromagnetic fields, as is true for powerlines throughout the United States.

Those fields will dissipate with increasing distance from the line. The powerlines will not radiate a directional beam as the CRS transmit antennas will. At distances within tens of ft from the line, interference with radio reception could result. That impact is typical of power lines and is not significant.

4.5.4 Mitigation Measures

The following are measures that would be implemented to mitigate the effects of EMI cat .ed by the CRS transmit facilities. Measures M4.5.1, M4.5.3, M4.5.4, M4.5.5, M4.5.6 and M4.5.7 are required to prevent significant impacts.

M4.5.1—To minimize the potential for interference with other transmitters in the 5-28 MHz band, use the assigned fixed service bands.

M4.5.2—To identify interference effects on amateur radio users, notify amateur radio users of possible effects and providing a means to report such EMI. Legitimate reports should be investigated to develop operational procedures to minimize EMI.

M4.5.3—If fundamental overload or high-power interference affects televisions CRS transmit site, the Air Force should install filters on the affected television or antenna.

M4.5.4—If harmonics of the CRS signal interfere with television reception, avoid using that frequency.

M4.5.5—To minimize potential effects on air navigation aids, do not use the subharmonic frequencies of VORs listed in Table 4.5.3.

M4.5.6—To reduce the risk to pacemaker owners, request that the FAA publish a NOTAM warning fliers to avoid close approach to the CRS transmit site and post notices on the exclusion fence. Permanent restrictions on air travel below 5,000 ft of elevation will be established in the area 5 nmi in from the CRS transmit site.

M4.5.7—To minimize hazards to EED users request that the FAA publish a NOTAM warning airman of the possible risk to planes carrying EEDs, notify all local and state governments and landowners within 19 mi of the transmit site of the EED hazard.

M4.5.8—If CRS interference with carrier-control circuits for nearby power lines, change the operating frequencies of those circuits to below 5 MHz.

4.6 BIOLOGICAL EFFECTS OF RADIOFREQUENCY AND POWERLINE FIELD RADIATION

4.6.1 Overview

This section examines the potential for exposure to non-ionizing electromagnetic radiation to cause harmful biological effects in humans. It summarizes [illegible]ation contained in the Technical Report: Analysis of the Potential for Electromagnetic Interference and Radiofrequency and Powerline Field Bioeffects, Central Radar System, Over-the-Horizon Backscatter Radar Program (SRI international, 1990). That report is based in part on a general review of RFR-bioeffects research entitled: Critique of the Literature on Bioeffects of Radiofrequency Radiation: A Comprehensive Review Pertinent to Air Force Operations (Heynick, 1987). The critique includes more than 500 detailed reviews of research projects, selected from the many thousands of accounts in the literature, on various RFR-bioeffects topics. Almost all papers selected were published in scientific journals.

The CRS transmit sectors will generate radiofrequency (RFR) radiation in the 5-28 MHz band. The sounder antennas and the communications link with Grand Forks AFB will also generate RFR, but at power levels orders of magnitude below the RFR from the transmit antennas. For that reason, this section focuses on the transmit antennas. The exclusion fence surrounding the CRS transmit sectors will prevent access by humans and large wildlife to the area of highest RFR levels, extending about 4,000 ft in front of the antennas. Outside the 4,000-ft exclusion area, the power densities will be below the current 1982 American National Standards Institute (ANSI)

standard (implemented by AFOSH 161-9) for human exposure to RFR in the frequency band used by CRS, and below the proposed Institute of Electronic and Electrical Engineers (IEEE) standard for human exposure to RFR. This section examines the basis for those standards and the potential for biological effects to result from CRS. The analysis herein concludes that no adverse effects on human health will result from human exposure to RFR outside the exclusion zone. Additionally, no adverse impact on wildlife is expected to occur within or outside the exclusion zone.

At the CRS receive site the communications link with Grand Forks AFB will be the only source of electromagnetic radiation. The link will be either a microwave, satellite, or tropospheric scatter radio system operating at a power level of about 500 W. That system would be similar to many existing communications systems, such as long-distance telephone and radios used for aircraft and marine communications. No available information suggests that biological effects could result from the low-power communications. Therefore, the CRS receive site is not analyzed further in this section.

Powerlines will be installed to supply electric power to the CRS. The powerlines serving the transmit site will be 115-kV lines while those serving the receive site will be 12.5 kV. Those lines will generate 60-Hz electromagnetic fields just as existing powerlines throughout the country do. Because there is some concern that biological effects could result from powerline fields, this section also examines the state of scientific knowledge regarding powerline field bioeffects and concludes that there is no proven scientific evidence of harmful health effects from powerline fields. However, more research is necessary and is underway to investigate some claims of biological effects from powerline-frequency fields.

4.6.2 Radiofrequency Radiation

4.6.2.1 Research Methodology

The acronym RFR is used here as a generic term to include other terms commonly found in the published literature on bioeffects, such as electromagnetic radiation (EMR), non-ionizing

electromagnetic radiation (NIEMR), electromagnetic fields (EMF), radiofrequency electromagnetic (RFEM) fields, microwave radiation, and microwave fields. The bioeffects literature encompasses studies from direct current to 300 GHz, and both amplitude-modulated and unmodulated frequencies.

Relatively few studies have been done on possible effects of human exposure to RFR at CRS frequencies (5-28 MHz), so the research results at those frequencies are given due prominence here. In addition, valid conclusions about possible RFR bioeffects at those frequencies are derived by careful extrapolation from research results at frequencies outside that range. It is important to recognize that knowledge in any discipline can never be complete, and it is impossible to prove with absolute certainty that any postulated phenomenon cannot or will not occur. Experimental findings are usually given in probabilistic terms because the data may contain various degrees of uncertainty.

The experimental evidence for any specific RFR bioeffect is derived primarily from the use of laboratory animals as surrogates for humans. Some investigations of human exposure to RFR have been done, either with volunteers or as epidemiologic studies. For ethical reasons, very few of the former have been conducted. On the other hand, epidemiologic studies elucidate the distribution of death or disease, often involving large human populations, and describe the factors that influence the distribution. However, for RFR as a possible factor, the numerical values of the exposure parameters (especially the intensity levels and durations) vary widely for each individual person, and are often uncertain.

For other agents, possible effects at very low levels are predicted by extrapolating findings at higher levels, on the basis of assumptions about the mathematical relationship between the level (or dose) of the agent and the degree of the effect. For RFR, such assumptions are open to challenge, and may lead to disagreement over the possible existence of a threshold dose or dose rate below which the agent has no effects.

4.6.2.2 RFR Safety Standards

ANSI Standard—Specific absorption rate (SAR) is the rate at which RFR electromagnetic energy is absorbed by the mass in any small volume of a body, expressed in watts per kilogram (W/kg). For any specific value of incident power density, the SAR usually varies with location in the body, so the term "whole-body SAR" is frequently used to represent the spatially averaged value of SAR.

In 1982, American National Standards Institute (ANSI) Subcommittee C95.IV adopted a frequency-dependent standard for both occupational and general-public exposure to RFR, to replace the 1974 ANSI Radiation Protection Guide (ANSI, 1982). The 1982 ANSI standard is based on a maximum whole-body SAR of 4 W/kg reduced by a safety factor of 10, or 0.4 W/kg, and it covers the frequency range from 300 kHz to 100 MHz. The limit is not to be exceeded for exposures averaged over any 0.1-hour period. The power density exposure standards are 36 mW/cm^2 to 1.15 mW/cm^2 for the range 5 MHz to 28 MHz. Outside the exclusion fence of the CRS transmitters, the average power density will be less than 0.1 mW/cm^2. The 1982 ANSI standard is implemented by AFOSH 161-9, which establishes policies, procedures, and acceptable exposure standards for the Air Force.

Proposed Institute of Electrical and Electronics Engineers (IEEE) Standard—In 1988, the functions of ANSI Committee C95 were transferred to Standards Coordinating Committee (SCC) 28, a new body under IEEE jurisdiction. The 1982 ANSI standard is being revised by Subcommittee IV of SCC 28, and the revision, entitled "American National Standard Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz" is expected to be issued in 1990.

Proposed Environmental Protection Agency (EPA) Standard—The EPA had been considered an exposure standard for the general population for several years, and was expected to issue its standard in July 1989. In September 1988, however, EPA stated that it no longer planned

to issue the standard during fiscal year 1989 or 1990. In the absence of a governing federal standard, various state, county, and municipal government bodies have issued ordinances on exposure of the general population to RFR that in some cases are considerably more stringent than the ANSI Standard. (ANSI, 1982)

Airborne Exposure—In sparsely populated regions such as near the CRS transmit study area, there are no FAA altitude restrictions for general aviation. People in airplanes may be exposed to the main beams of the CRS transmit antennas. However, the Air Force will request the FAA to issue a formal "Notice to Airmen" (NOTAM) to avoid the CRS transmit site, but even with a NOTAM, it is possible that people in small aircraft may occasionally fly past the transmit site and be exposed to the main beam for short periods.

Calculations show that at distances more than about 3,200 ft in front of the transmitter antennas, the maximum average power density along the main beam would be less than the levels specified in either the 1982 ANSI standard for the general population or the proposed 1990 IEEE revision. However, the likelihood of any aircraft flying so close for any substantial amount of time is very small. Moreover, if the aircraft skin were metal, it would provide considerable protective shielding. Thus, it is most unlikely that people within aircraft would suffer health effects directly related to RFR exposure.

Ground-Level Exposure—The ground-level distance at which the average power density will equal the power density specified in the 1982 ANSI standard for public exposure to RFR will be about 1,250 ft. For the proposed IEEE 1990 standard, the safe distance would be 2,140 ft. Thus the exclusion fence to be placed 4,000 ft in front of the antennas would prevent human exposure to ground-level power densities exceeding the 1982 ANSI radiation protection standard for the general population and the proposed 1990 IEEE revision.

4.6.2.3 Interactions with Living Organisms

Non-ionizing radiation (such as RFR) and ionizing radiation have differing effects on living organisms. Ionizing radiation, which includes ultraviolet light, X-rays, and the emissions from radioactive materials, contains enough energy to expel an electron from a molecule, leaving the molecule positively charged and thereby strongly affecting its interactions with neighboring molecules. That can alter biological molecules fundamentally and irreversibly.

In contrast, non-ionizing radiation (RFR) is usually absorbed macroscopically in the form of heat, defined as an increase in the mean random speed (or kinetic energy) of the molecules (a local temperature rise) or as an increase in the disorder or randomness of molecular motion. Increases in molecular motion caused by RFR are evanescent and begin to diminish as soon as exposure is halted. At relatively low RFR intensities (depending on the animal species), the heat induced usually can be accommodated by the thermoregulatory capabilities of the species, and thus any effects produced would generally be reversible. At high intensities, the thermoregulatory capabilities of any given species may be exceeded, which could lead to thermal distress or even irreversible thermal damage.

The large body of experimental data on RFR bioeffects indicates that, unlike the ingestion of certain substances in small quantities that can accumulate into a potentially harmful total dose, the RFR energy that is continually absorbed at low incident power densities (dose rates) is readily dissipated and does not accumulate in the body toward a total dose equivalent to the RFR energy absorbed in short exposures at high incident power densities. This is a basic reason for the existence of RFR-bioeffects threshold levels.

RFR is reflected and refracted at boundaries between regions of differing dielectric properties, such as at the air-surface interface of a body. This is also true at internal boundaries between constituents of widely different dielectric properties. In the range 3 MHz to 30 MHz, about 85-

95% of the incident power density is reflected at the air-skin boundary, and approximately 5-15% enters the body.

In the RFR-bioeffects literature, thermal energy absorption from an incident electromagnetic field is generally quantified by the specific absorption rate (SAR). The SAR is the rate of energy absorbed by the mass of the constituents per volume, expressed in watts per kilogram (W/kg). Whole-body SAR, the spatial average SAR for the body, is useful because it can be measured experimentally without requiring any information on the internal SAR distribution. The largest value of whole-body SAR occurs when the wavelength of the incident RFR is about 2.5 times the longest dimension of the body, which is called the resonant frequency. The resonant frequency for an "average" man, 5 ft 9 in. tall, is about 70 MHz. At this frequency, the whole-body SAR is about 0.2 W/kg for an incident power density of 1 mW/cm^2. At that SAR, exposure of a man to 1 mW/cm^2 for 1 hour would produce a mean temperature rise of about 0.2°C in the absence of any heat-removal mechanisms. But at 30 MHz, which is below the resonant frequency, the whole-body SAR is only about 0.02 W/kg per mW/cm^2 and exposure at 1 mW/cm^2 for 1 hour would cause a mean temperature rise of only about 0.02°C. The resonant frequency for an "average" woman, about 5 ft 3 in. tall is about 80 MHz and, for a 10-year-old child, about 95 MHz. Outside the exclusion fence, the maximum incident power densities at all CRS frequencies would be 0.1 mW/cm^2 or less. Thus, the likelihood of a rise in body temperature from heating by exposure to the RFR levels outside the exclusion fence is negligibly small.

4.6.2.4 Present State of Knowledge

This section summarizes the findings of the Technical Report (SRI International, 1990) regarding the current understanding of the relationship between exposure to RFR and biological effects.

Epidemiological and Occupational Studies—Epidemiologic studies are those in which the investigators sought to determine if health-related conditions are statistically associated with

purported or actual exposure of segments of the general public to RFR. Usually, the RFR-exposure characteristics (frequencies, levels, and durations) in epidemiologic studies are either unknown or coarsely estimated. Among the papers that reported negative results were those that described studies on males who had served in the Navy during the Korean War. (Robinette and Silverman, 1977)

The U.S. Embassy in Moscow was irradiated with low-level RFR at microwave frequencies from 1953 until February 1977. Lilienfeld et al. (1978) conducted a study on the health of 1,827 U.S. personnel assigned to the Moscow embassy and 1,228 dependents. No discernible differences were found between Moscow and control groups in total mortality or mortality from specific causes, nor were there significant mortality differences between Moscow and control groups of adults or dependent children.

In one of a pair of studies, Lester and Moore (1982a) endeavored to establish an association between mortality from cancer and proximity of the residents to Air Force bases. However, that study was flawed by incorrect assembly of the data base. Polson and Merritt (1985), in an independent correct assembly and statistical analysis of the data, showed that cancer incidence for either sex in counties that had Air Force bases did not significantly differ from the incidence in counties that did not have Air Force bases.

In the second study, Lester and Moore (1982b) sought to determine whether there was a geographic pattern of cancer incidence within the city of Wichita, Kansas. They reported finding a neighborhood pattern of cancer incidence and noted that cancer tended to occur more frequently for persons located on elevated topography relative to radar transmissions from Wichita Mid-Continent Airport and McConnell Air Force Base. However, the authors did not cite measurements of RFR levels or use a model of RFR propagation to determine exposure levels. Thus, the conclusions drawn in the paper are unwarranted.

Considerable weight should be accorded findings of well-performed studies involving actual or presumed human exposure to RFR. Analyses of the findings of various epidemiologic studies on the effects of exposure to RFR, either occupationally or from residing in the neighborhood of RFR emitters, and those of several studies with human volunteers, produced no unequivocal evidence that chronic exposure of humans to RFR at levels conforming with the 1982 ANSI exposure standard or its proposed 1990 revision would cause adverse health effects.

Congenital Anomalies—Two studies were done that sought a possible relationship between the occurrence of Down's syndrome (Mongolism) and the presumed exposure of the fathers to RFR from radars during military service. (Sigler et al., 1965; Cohen et al., 1977) The authors of the first study concluded that: "The only truly puzzling association is the suggested relationship between Mongolism and paternal radar exposure." A second study reexamined the data in the first study together with additional data and did not confirm the suggestion that Down's syndrome was correlated with previous radar exposure or military experience of the child's father .

Peacock et al. (1971 and 1973) endeavored to assess whether the incidence of birth defects in Alabama could be associated with the proximity of military bases. A second study confirmed that the total anomaly rate and the rates for several specific anomalies were abnormally high at Lyster Hospital at Fort Rucker. Burdeshaw and Schaffer (1977) reexamined the original Alabama birth records, but compared the data for Coffee and Dale Counties (within which Fort Rucker is located) with the data from each of the other 65 counties in Alabama on a score and rank basis instead of the statewide averages. They found little evidence that the incidence of congenital anomalies in the Fort Rucker area was unusually high.

Kallen et al. (1982) hypothesized that physiotherapists (in Sweden) were likely to have been occupationally exposed more to various agents (chemicals, drugs, X-rays, RFR) than the general population. They concluded that the physiotherapists as a group had a slightly better-than-expected outcome for prenatal deaths and major malformations than did the general Swedish population.

However, among physiotherapists, the use of shortwave equipment was higher for those who gave birth to a malformed or prenatally dead infant.

In conclusion, studies on congenital anomalies or prenatal infant deaths have yielded no conclusive evidence that such effects have been caused by chronic exposure to RFR at levels below current U.S. exposure standards, or specifically that the RFR from the CRS transmit antennas would cause such effects in the human population outside the exclusion fence.

Ocular Effects—If a person's eyes are exposed to intensities high enough to elevate the temperature of the lens by about 5°C (9°F) or more, the lens quickly suffers damage. The lens is the region of the eye most vulnerable to RFR at high levels because other regions have more effective means of heat removal, such as greater blood circulation. For this reason, the basic concern about ocular effects is whether continuous or intermittent RFR exposure for long periods at levels that would produce little or no rise in lens temperature can cause eye damage, which would indicate that the effects of chronic low-level exposures of the eye are cumulative. The following results by Guy et al. (1975a) are representative of a number of studies on the effects of RFR on the eyes of live animals done during the past several decades:

(1) For the formation of cataracts, there is an inverse (reciprocal) relation between incident average power density and exposure duration. That is, less time is required for high power densities to cause cataracts.

(2) Increases in intraocular temperature of about 5 ^{o}C or more are necessary for eye damage.

(3) The threshold power density for indefinitely long exposure to 2.45-GHz RFR without effects is roughly about 150 mW/cm^2 (138 W/kg).

(4) Opacifications resulting from exposure to RFR without effects levels above the threshold are not produced at the same levels when the eye is cooled during exposure, showing that cataract causation by RFR is essentially a gross thermal effect.

Various epidemiologic studies expressly on possible ocular effects of RFR have been done. In three studies (Appleton and McCrossan, 1972; Appleton, 1973; Appleton et al., 1975), surveys were conducted of the eyes of personnel at Army posts where various types of electronic communication, detection, guidance, and weather equipment were under development, testing, and use. The authors concluded that the available clinical evidence does not support the assumption that cataracts in personnel performing duties in the vicinity of microwave-generating equipment are a result of microwave exposure.

In summary, some of the epidemiologic studies on possible ocular damage from human exposure to RFR yielded negative findings; in others, some differences in eye changes between "exposed" and "control" groups were reported, but the presence of possible non-RFR factors could not be ruled out. Possible exceptions are individual cases of occupational exposure to RFR at levels and durations that might have been sufficient to heat the eye to temperatures well in excess of those found to be damaging in animal experiments. In any case, there is no evidence that prolonged exposure of humans to the RFR from the CRS transmit antennas at the levels outside the exclusion area would cause eye damage.

RFR Shock and Burn—Several studies have attempted to determine the RFR levels and conditions that could cause electric shock or tissue burns. Rogers (1981) described an apparatus for measuring RF currents that pass through a human in shoes standing on a ground plane. That apparatus was used to measure the current that yielded a barely perceptible sensation ("perception" current) and the values that caused discomfort ("let-go" or "hazard" current) for frequencies in the MF (0.3-3 MHz) and HF (3-30 MHz) bands. The results for 50 persons showed a mean hazard threshold current of about 200 mA for the band 3-30 MHz.

Gandhi and Chatterjee (1982) calculated the short-circuit currents induced in metallic objects and then calculated the electric fields necessary for threshold-perception and let-go currents of a human in finger contact with each object. Threshold-perception current was found to rise from

about 0.4 mA at 10 kHz to about 100 mA at 20 MHz. Let-go current also rose, from 6.4 mA at 10 kHz to about 200 mA at 20 MHz. The authors noted that based on an equivalent circuit of a human in conductive contact with an ungrounded, metallic object in a quasi-static HF field, there may be situations where the thresholds for perception and let-go can be exceeded for fields considerably lower than the 1982 ANSI far-field guideline in the frequency band 0.3-3.0 MHz. They also noted that the effects do not occur when the conducting objects are grounded or insulated at the points of possible contact.

The proposed 1990 IEEE revision of the 1982 ANSI standard for the general population (in uncontrolled environments) includes a limit of 45 mA through each foot for induced current and the same limit for contact current in the range 0.1-100 MHz. The CRS transmit antennas would generate RFR levels outside of the exclusion area that conform with that standard. The CRS would not cause persons outside the exclusion area to experience shock or burn.

Mutagenesis, Cytogenetic effects, and Carcinogenesis—Mutagenesis and carcinogenesis are considered to be related, and many chemicals are screened for potential cancer-causing properties by testing whether such chemicals produce mutations in specific bacteria. Blackman et al. (1976), Dutta et al. (1979), and Anderstam et al. (1983) investigated whether RFR is mutagenic for E. coli or Salmonella bacteria. No significant differences in genetic activity between exposed and control groups were found.

Bioeffects of exposure of rats to electromagnetic pulses (EMP) were sought by Skidmore and Baum (1974). Those authors exposed male mice to EMP. After 33 weeks of exposure, the difference in leukemia rate for exposed mice and control mice was nonsignificant. The authors also sought possible effects of EMP on fertility by exposing male/female pairs of rats for 13 weeks. No anatomical abnormalities were found, and there were no significant differences in numbers of progeny of control and exposed groups.

There is no evidence that exposure to RFR induces mutations in bacteria, yeasts, or fruit flies except for conditions that cause significant temperature rises in the specimens. Several studies showed that exposure of male rodents to power levels of RFR that produce heating of the testes tend to reduce fertility, but such levels were not found to be mutagenic. There is no confirmed evidence that chronic RFR exposure induces or promotes any form of cancer in mammals, a finding applicable to the RFR frequencies and levels of the CRS.

Teratogenesis—Teratogenesis refers to the causation of anatomical aberrations in a developing fetus, but more generally also includes fetal death and/or postnatal abnormalities in the offspring. Carpenter and Livstone (1971) exposed darkling beetle pupae to 10-GHz RFR at about 17 mW/ cm^2 (40 W/kg) for 2 hours. As representative results, only about 20% of the exposed pupae developed into normal beetles; in contrast, 90% of the sham-exposed pupae developed normally. Liu et al. (1975) exposed pupae to 9-GHz RFR and found significant teratogenesis for 2-hour exposures at as low as about 0.17 mW/cm^2 (0.41 W/kg). On the other hand, Pickard and Olsen (1979) showed that the occurrence of abnormalities depended strongly on non-RFR factors. The variations in results among the various studies appear to have been due to uncontrolled differences in such factors as the source of the larvae, the maintenance regimes and handling protocols for the pupae, the pupae containers used for pupation, and ambient temperature.

McRee et al. (1975) and Gildersleeve et al. (1987) found no significant differences between the hatchlings from RFR-exposed and sham-exposed eggs of Japanese quail. The results indicated that exposure to RFR during embryogenesis did not affect hatchability, mortality after hatching, egg production, egg weight, fertility, or reproductive performance.

In some studies with mice, RFR exposure has been reported to cause various teratogenic effects, but negative or inconsistent results were obtained in others. (Chernovetz et al., 1975; Berman et al., 1978, 1982a; Stavinoha et al. 1975; Tofani et al., 1986; Kaplan et al., 1982;) In summary the results show that a threshold of heat induction or temperature increase must be

exceeded to produce teratogenic effects. Because the normal human metabolic rate is about 1-2 W/kg, the RFR power densities generated outside the exclusion fence by the CRS transmit antennas would not cause significant heating of humans.

Nervous System—Concern has been expressed that direct (nonthermal) interactions of RFR with the central nervous system could produce deleterious effects, including alterations in behavior, passage of foreign agents from the vascular system of the brain into the surrounding tissue due to opening of the blood-brain barrier (BBB), changes in the histopathology and histochemistry of the nervous system and of the electroencephalogram (EEG), and changes in the efflux of calcium from brain tissue. In an early study, rats were exposed to 1.3-GHz pulsed or CW RFR at levels up to 3 mW/cm^2 (about 0.6 W/kg), and BBB-permeability changes were determined. Endeavors by Merritt et al. (1978) and more recently by Ward and Ali (1985) to reproduce the findings of the early studies were unsuccessful. On the basis of current evidence, it is quite unlikely that exposure to the levels of RFR existing near ground outside the exclusion fence of the CRS transmitter site would have any effect on the permeability of the BBB because the levels of RFR would be too low to cause brain heating.

Neural histopathologic and histochemical studies are, respectively, those of diseased or damaged neural tissues and chemical composition of such tissues. RFR in the UHF region evidently can cause observable histopathological and histochemical changes in the central nervous system of animals, but most of the positive findings were thermally induced. (Chou and Guy, 1978; Rabinowitz, 1978) On the other hand, changes in ATP and CP concentrations in rat brains were induced by exposure to 591-MHz without measurable tissue hyperthermia. (Sanders et al., 1985) The significance of those findings with regard to possible human health hazards is not clear at present. Merritt and Frazer (1975) exposed mice to 19 MHz RFR with no increase in concentrations of neurotransmitters in the brain. In view of the negative findings at 19 MHz, it is unlikely that any effects would occur at the RFR levels outside the CRS transmit-site exclusion area.

Studies of EEG and evoked potential changes have been performed to ascertain the effects of RFR on the EEG or on the potentials evoked by visual or auditory stimuli. Early studies that attempted to measure EEG changes during RFR exposure used electrodes and leads that picked up electrical signals directly from the RFR fields. In addition, indwelling or chronically attached electrodes perturbed the electric fields in their vicinity and yielded considerable enhancement of energy absorption, thereby creating still another artifact in the EEG data. However, in a few of the more recent studies, those problems were minimized by the use of specially designed indwelling electrodes of high-resistivity materials that do not cause field perturbation. Experiments in which such specially devised electrodes were used, or in which electrodes were applied after exposure, yielded no evidence of significant differences in EEGs or in evoked responses between control and RFR-exposed animals. Ground-level RFR from the CRS transmit antennas would not be likely to cause any effects on the EEG or evoked potentials of populations outside the exclusion fence.

Immunology and Hematology— Many reports indicate that RFR has specific effects on the immune systems of mammals. Most reported effects were detected after exposure at power densities of 10 mW/cm^2 and higher; a few effects have been found from exposure to levels as low as about 0.5 mW/cm^2. In most of the studies, the mechanisms for the effects were not investigated, and many of the results were not consistent with one another.

Early studies were done *in vitro* to determine whether RFR exposure can stimulate lymphocytes (one type of leukocyte or white blood cell) to become lymphoblasts and to undergo mitosis. Various studies of RFR interactions with red blood cells (RBCs) *in vitro* sought alteration of cell membrane function and particularly any effects on the movement of sodium ions (Na+) and potassium ions (K+) across the membrane.

Studies of immunological effects of RFR *in vivo* can be divided into those in which changes in specific immunological parameters were sought, and those in which effects of RFR on the health of the subjects and their resistance to disease were examined. Relatively few investigations have

been donᴇ :o determine whether chronic RFR exposure affects the general health or longevity of animals, or alters the resistance to, or the severity of, diseases accidentally acquired or purposely given to animals.

Much early work toward searching for possible effects of RFR on suspensions of various classes of leukocytes exposed *in vitro* suffered from the lack of adequate control of cell temperature during exposure. In later studies where effective control over culture temperature was exercised, nonsignificant differences were obtained with exposed cultures held at the same temperature as control cultures. In those studies where the culture temperature was elevated by RFR, the effects were clearly of thermal origin.

Studies seeking immunological effects of exposing animals to RFR *in vivo* yielded mixed results. Some investigators found that RFR exposure of mammals increased the proliferation of leukocytes or the production of antibodies (relative to controls), but with few exceptions, the measured or estimated SARs were well in excess of 1 W/kg. More subtle effects on mammalian immune systems were sought in more recent studies, making use of significant advances in assay methods and with attention to possible effects of non-RFR stress. Some of those investigations were directed toward the effects of RFR on the activity of natural killer (NK) cells, the results of which again showed that SARs much higher than 1 W/kg were necessary for effect.

More directly relevant to possible RFR effects on the human immune system would be studies in which animals are chronically exposed to RFR (preferably over virtually their entire lifetimes), to determine whether such exposure adversely affects their health, longevity, and resistance to natural disease or experimental challenge with various microorganisms or toxins therefrom. Some studies indicated that animals exposed to RFR for relatively short periods can withstand bacterial infection better than sham-exposed animals. Because of funding limitations, however, few studies involving chronic RFR exposure were carried out or repeated by other laboratories.

Probably the most comprehensive chronic investigation to date was that of Guy and coworkers (1983), who exposed 100 rats to RFR and concurrently sham-exposed 100 other rats for essentially their full lifetimes (except those withdrawn for interim tests and those that expired before the end of the exposure regimen). Tests on 10 RFR- and sham-exposed rats withdrawn after 13 months of treatment (interim kill) showed counts of splenic T- and B-lymphocytes that were significantly higher for the RFR than the sham group, an effect ascribed to stimulation of the lymphoid system by the RFR. However, this effect was absent in similar tests on completion of treatment. Longevity of the rats was not affected by the RFR at corresponding times during the exposure regimen.

No primary malignancies were found at the interim kill (in the rats younger than one year). However, the most controversial finding was that among those rats older than one year, primary malignant lesions (of various kinds) were found in a total of 18 of the RFR-exposed rats but only 5 of the sham-exposed rats. The authors gave several arguments to discount the biological significance of this finding. The difference between the RFR- and sham-exposed rats in number of cases of each specific malignancy was nonsignificant and because the numbers were so small, statistical significance could be attained only by combining them, an oncologically dubious procedure.

In conclusion, there is no evidence that reported effects of RFR on the immune systems of animals would occur in humans chronically exposed at ground-level outside the exclusion fence to RFR from the CRS transmitters.

Physiology and Biochemistry—The literature on physiological and biochemical effects associated with exposure to RFR is extensive. Of particular interest with regard to the CRS are several primate studies in the HF region (3-30 MHz). (Bollinger, 1971; Frazer et al., 1976; Krupp, 1977 and 1978) The results showed that heat gain caused by RFR exposure was readily accommodated by the primates' thermoregulatory mechanisms. No RFR-related variations from

the normal values of hematologic and biochemical blood indices or of physical conditions were found.

Ho and Edwards (1979) used oxygen-consumption rate as an indicator of stress in mice. Mice exposed to 2.45-GHz sought to diminish their thermal burdens by altering their body configurations during exposure to minimize the RFR-absorption rates; they also reduced their oxygen consumption. After exposure completion, oxygen consumption rates returned to normal.

The thermal basis for various effects of RFR on the autonomic thermoregulatory systems of mammals and their behavioral thermoregulatory responses to RFR is evident. Especially noteworthy are the results for primates and their ability to compensate for RFR-induced heating, because of their similarity to humans. Based on those results, it is most unlikely that humans exposed to the RFR from the transmitters of the CRS at the levels outside the exclusion fence would be adversely affected.

Endocrinology—Exposure of mammals to RFR has yielded rather inconsistent effects on the endocrine system. Although some effects of RFR exposure on the endocrine system appear to be straightforward and predictable from physiological considerations, other, more subtle effects may be worthy of additional study, such as those related to the interactions among the pituitary, adrenal, thyroid, and hypothalamus glands and/or their secretions. Part of the problem in interpreting such results appears to be related to the uncertainties about stress mechanisms and various accommodations to such mechanisms. Animals placed in novel situations are much more prone to exhibit stress responses than those adapted to experimental situations.

Because the effects of RFR on the endocrine systems of animals are largely ascribable to increased thermal burdens, to stresses engendered by the experimental situation, or to both, there is no clear evidence that such effects would occur in humans exposed to RFR at levels that do not produce significant increases in body temperature, and specifically from the CRS transmit antennas outside the exclusion area.

Cardiovascular Effects—Few investigations were carried out on possible effects of RFR on the human heart. By contrast, various studies were performed *in vitro* on hearts (or parts thereof) excised from animals (Frey and Seifert, 1968; Clapman and Cain, 1975; Liu et al., 1976; Galvin et al., 1981B; Yee et al., 1984), and others were done on animal hearts *in vivo*. (Presman and Levitina, 1963; Phillips et al., 1975; Galvin et al, 1981A; Galvin and McRee 1986)

Positive findings were reported in early studies, but are suspect because of the use of attached or indwelling electrodes that probably introduced artifact. Various kinds of electrodes were investigated, and special types were developed that were not perturbed by RFR or did not perturb the local RFR fields. Studies involving use of such electrodes showed that heart rates were altered only at RFR levels that produced rises in temperature or otherwise added thermal burdens to the animal.

Several researchers showed that for CW RFR, levels well in excess of 1 mW/cm^2 or 1 W/kg were necessary for significant alterations of heart rate. Small bradycardia levels were seen in equilibrated conscious rats exposed for 6 hours at 3.7 W/kg, a finding ascribed to a compensating reduction in metabolic rate. The results of another study indicated that functioning of hearts damaged from other causes is not affected by exposure to CW RFR at 10 mW/cm^2 or lower.

Based on the foregoing, there is no evidence that exposure of humans to the RFR from the CRS transmitters at the levels outside the exclusion fence will be hazardous to their cardiovascular health .

Behavior—Numerous studies have been done on possible effects of RFR exposure on various kinds of animal behavior. D'Andrea et al. (1986a) adapted 28 rats to exposure chambers and divided them into two groups of 14 each. One group was exposed for 7 hours per day on 90 consecutive days, totaling 630 hours, to 2.45-GHz CW RFR at 0.5 mW/cm^2 (0.14 W/kg), and the other group was sham-exposed. Body masses and intake of food and water were measured daily. Each rat was tested monthly for its threshold reactivity to footshock. The differences in body

masses, food and water intake, or threshold footshock reactivities between the groups were not significant.

After the 90 days of treatment, seven of each group were assessed for open-field behavior, shuttlebox performance, and lever pressing for food pellets on an interresponse time schedule. There were major changes in both tests over daily trials but no significant differences ascribable to RFR exposure. The results of the study above and of two similar studies in the same laboratory (D'Andrea et al., 1986b; DeWitt et al., 1987) were not fully consistent and exhibited little if any statistically significant differences between RFR-exposed and sham-exposed rats, but suggested that the threshold for behavioral responses to 2.45-GHz RFR in rats may be in the range 0.5-2.5 mW/cm^2 (0.14-0.70 W/kg).

Galloway (1975) exposed rhesus monkeys to estimated mean head SARs of 7, 13, 20, 27, and 33 W/kg. For studying discriminative behavior, the RFR was administered for 2 minutes just before each behavioral session but was terminated earlier if the monkey began to convulse. No effects on discriminative behavior were evident for either exposure regimen. In a repeated-acquisition test, each monkey had to press the correct lever for each of four illumination stimuli in the proper sequence. An incorrect lever press caused a 15-second timeout, during which any lever press had no effect. The RFR had no effect on this behavioral paradigm.

Cunitz et al. (1975) trained a 3-kg and a 5-kg rhesus monkey on a four-choice, forced-choice serial reaction program. Each monkey was exposed to 383-MHz RFR during the entire 2-hour session at a fixed level in the range 0-15.0 W. The head SARs were estimated to range up to 33 and 23 W/kg respectively. Exposures below 10 W did not alter either monkey's performance. The lowest head SARs for diminished performance by the two monkeys were about the same: 22 and 23 W/kg.

Scholl and Allen (1979) trained three rhesus monkeys in a visual-tracking task that required each monkey, seated in a restraining chair, to move a lever to hold a continuously moving spot

within a prescribed clear area on the screen of a display monitor. After training, the monkeys were exposed to horizontally polarized, 1.2-GHz CW RFR at 10 and 20 mW/cm^2 for 2 hours per day at two-day intervals until each was exposed for 120 minutes at each level. The corresponding head SARs were 0.8 and 1.6 W/kg. The performance of the monkeys was not significantly degraded.

De Lorge (1976) trained five rhesus monkeys to perform the following task while seated: Each monkey was required to press a lever in front of its right arm, thus producing either a low-frequency tone for 0.5 second to signal that no food pellet will be coming, or a higher-frequency tone for which the monkey had to press a lever in front of its left arm to receive a pellet. The monkeys were exposed to pulsed RFR at 4 or 16 mW/cm^2 (0.4 or 1.6 W/kg head SAR) for 30 minutes. Similar sessions were conducted with the unpulsed RFR and with no RFR. At either level, the performances of the monkeys were not affected by either the unpulsed or pulsed RFR.

De Lorge (1979) also trained four squirrel monkeys in 1-hour sessions to press either the right or the left lever on top of a chair. Each right-lever response yielded either 0.5 second of red light or 10 seconds of blue light. Only a left-lever press during the latter yielded a pellet. After stable behavior was achieved, each monkey was exposed from above to 2.45-GHz RFR at levels in the range 10-75 mW/cm^2. SARs were estimated to have been 0.5 to 3.75 W/kg. No consistent behavioral changes occurred below 50 mW/cm^2 (2.5 W/kg); above that level, the effects increased with RFR level. The author concluded that the behavioral changes were temporary and clearly related to hyperthermia.

The findings of the De Lorge study, reinforced by the similar results with rhesus monkeys, are important because the measurements of performance of a complex behavioral task during exposure to RFR were carried out with two species much closer to human physiology and intelligence than more commonly used non-primate laboratory animals, and because reasonably accurate RFR thresholds for each primate species were determined.

RFR and Drugs—Various studies have been conducted on possible interactive effects of exposure to RFR and medications or other drugs taken or administered. The relatively few studies of possible synergism between RFR and psychoactive drugs such as diazepam, chlorpromazine, chlordiazepoxide, and dextroamphetamine yielded unclear or inconsistent results. In some studies, the changes in drug dose-response relationship were subtle and not necessarily induced by the RFR. In most of the studies that yielded RFR-induced changes in drug response, average power densities of 1 mW/cm^2 or higher coupled with relatively high drug dosages were necessary. The results were negative in still other studies. Noteworthy were negative findings of synergistic effects between alcohol consumption and exposure to RFR except at very high alcohol doses.

In general, it seems unlikely that the effects of psychoactive drugs prescribed by physicians or those of consumed alcohol would be altered by exposure to environmental levels of RFR, specifically at those outside the exclusion fence of the CRS transmitters.

Cellular and Subcellular Effects—Many of the early studies on microorganisms produced results that were taken as evidence of nonthermal effects of RFR. The existence of resonances at frequencies above 30 GHz was postulated on theoretical grounds, and several studies were done that appeared to confirm that hypothesis. However, later studies with the use of more sophisticated engineering and biological techniques and in which artifacts were reduced significantly yielded results that did not confirm earlier findings of resonances or other evidence of nonthermal effects at such frequencies.

Apparent absorption resonances in the range 2-9 GHz reported for aqueous solutions of DNA molecules derived from E. coli were regarded as indicative of direct action of RFR with such molecules. Later endeavors to reproduce such findings, however, yielded negative results. Moreover, analytical and experimental results were obtained indicating that such resonances were most likely artifactual, associated with the measurement methodology used.

In general, research on possible RFR effects on microorganisms or of RFR exposure *in vitro* of cells derived from macroorganisms appears to be useful toward eliciting possible mechanisms of direct interaction of RFR with such biological entities or their constituents at levels that can be characterized as nonthermal. Open to question, however, is the relevance of such findings to possible effects of exposure of intact animals to RFR and ultimately the significance of such findings with regard to possible hazards of RFR to humans.

4.6.2.5 Unresolved Issues and Conclusions

The potential biological effects of RFR at frequencies between 10 kHz and 300 GHz have been assessed from representative peer-reviewed studies published in the scientific literature. The preponderance of reliable evidence in the investigations indicates that chronic exposure to RFR at average power densities generally found in the environment is not hazardous to human health. Nevertheless, there are uncertainties regarding biological effects of RFR worthy of mention. Such uncertainties may be reduced but are not likely to be eliminated entirely in the foreseeable future.

(1) Many of the epidemiologic studies on the bioeffects of RFR were extensive, but contained defects such as imprecise assignment of individuals to exposure and control groups; classification of the individuals in the exposure groups with regard to the frequencies, levels, and durations of exposure; and difficulties in obtaining complete or accurate medical records, death certificates, or responses to health questionnaires. With the availability of periodically updated computer-archival data bases on human health, it is very likely that considerable improvements can be obtained in the records aspects for possible future epidemiologic studies.

(2) Applying results on laboratory animals to humans by extrapolation or otherwise, though essential, is an expedient that contains fundamental problems and uncertainties due to the basic differences between humans and other species. Investigations with nonhuman

primates considerably narrow the interspecies gaps, but at costs that are often prohibitive. Thus, majo: reductions in such uncertainties seem unlikely, at least in the near future.

(3) The results of many investigations indicate the existence of threshold RFR levels for various bioeffects, thus providing confidence that exposure to levels that are appreciably below the thresholds are most unlikely to be deleterious. However, most experimental data that indicate the existence of thresholds were obtained by use of single or repetitive exposures of relatively short durations. Very few investigations have been done that involve essentially continuous exposure of animals to low-level RFR (below threshold levels or those that can cause significant heating) during most of their lifetimes. The high costs of such investigations are a major impediment to their pursuit.

(4) Regarding the basic mechanisms of interaction between RFR and various biological entities, many important discoveries have been made recently, notably by exposure of cells and subcellular structures and constituents *in vitro* to relatively low levels of RFR. The effects on such entities can be characterized as nonthermal, but extrapolation of such effects to possible health effects on intact humans or animals is difficult and uncertain.

Based on the foregoing, it is unlikely that new experimental information would reveal any hazard from chronic exposure to low levels of RFR. Nevertheless, there are unresolved issues concerning nonthermal effects and their significance. On the other hand, it is noteworthy that to date, the U.S. Environmental Protection Agency has been unable to characterize chronic exposure to environmental levels of RFR as hazardous based on mortality or morbidity data in the general population.

This review of the literature on RFR bioeffects has examined the scientific basis for a number of different types of reported effects. In many cases, there is a threshold level above which the reported effect occurs. In the case of ocular effects; mutagenesis of bacteria, yeast, and fruit flies; teratogenesis; immunological effects; effects on the heart and endocrine system; BBB effects; and

behavioral changes in primates, heat loading due to RFR caused the observed effect. Because the power densities generated by the CRS outside the exclusion area would be readily compensated for by human thermoregulatory systems, those health effects would not result from exposure to the CRS energy. Studies on primates have confirmed that the thermoregulatory system of primates can compensate for levels of RFR exposure at or below the 1982 ANSI standard as implemented by AFOSH 161-9.

Early studies of possible cogenital and EEG effects from RFR suffered from inadequate methodology and procedures. More recent studies have indicated that those effects are unlikely to result in mammals from RFR exposure. Additionally, there is no firm evidence that exposure to RFR at any level could result in carcinogenesis in mammals.

Histochemical changes without heating have been recorded in rats exposed to 591 MHz RFR. (Sanders, et al, 1985) However, no similar effects were recorded in mice exposed to 19 MHz RFR. (Merritt and Frazer, 1975) The significance of the effects found in the rats is not known and bears further study. Given the negative findings for mice exposed to CRS-frequency RFR, there is no reason to believe that harmful effects would result from CRS.

Shock and burn can result from contact with metallic objects exposed to RFR. The proposed 1990 IEEE standard for RFR exposure is designed to prevent shock and burn effects. Outside the exclusion area, CRS would conform with that standard, and no effects would be expected.

In summary, while RFR bioeffects can result at power densities above the existing 1982 ANSI and the proposed 1990 IEEE standards, there is no evidence that bioeffects would occur at exposure levels conforming with those standards. The CRS would include an exclusion area to prevent human exposure to RFR levels exceeding those standards. Based on the foregoing, there is no valid evidence that chronic exposure to the RFR from the CRS transmitters at the levels beyond the exclusion fence will have any adverse effects on human health.

4.6.2.6 Effects on Wildlife

Airborne Exposure—Animals that could be affected by the main beam from the CRS transmit antennas include birds in flight and possibly bats and high-flying insects. The RFR-bioeffects literature suggests that biological effects, not necessarily hazardous, are possible at average power densities exceeding 1 mW/cm^2. Under worst-case conditions, time-averaged power densities will exceed 1 mW/cm^2 at distances along the main beam up to 1,550 ft and elevation angles up to about 10°. The highest instantaneous power density will be about 260 mW/cm^2, which will be encountered at altitudes up to about 63 ft within 253 ft along the main beam. The maximum exposure duration would be but a few minutes for airborne organisms that traverse these regions.

For local airborne animals, minor effects could result within 1,550 ft of the antenna. The RFR from CRS might tend to cause birds to avoid the radar, thus eliminating the possibility of their striking it. (Tanner and Romero-Sierra, 1969) On the other hand, birds might learn to seek out the RFR for warmth during cold weather. (Gandhi et al., 1980) On the basis of existing information, the anticipated effects, if any, on birds are unclear. Moreover, RFR-induced biological effects may vary among bird species because the SARs may be species-dependent. However, any potential thermal effects would be of short duration and localized.

Nonthermal effects on birds from low-level RFR have been claimed by a few researchers (Tanner, 1966; Tanner; et al, 1967), but the methodology used in these experiments has been questioned. (Eastwood, 1967; Krupp, 1976) Temperature measurements of the experimental subjects were not made, and the effects may have been thermal. Irrespective of whether the effects were thermal or nonthermal, the experimental arrangements (caged birds in highly restricted areas with horn antennas mounted on the cages) bear little relationship to the habitats in which a bird normally operates.

Effects of exposure of insects to RFR range from unrest to death, depending on the level and duration of the exposure and the species studied. (Gary and Westerdahl, 1978) In laboratory

studies, abnormal development of beetle pupae was reported at power densities and exposure durations that produced significant heating. In one study (Westerdahl and Gary, 1981), adult honeybees were exposed to 2.45-GHz CW RFR at power densities from 3-50 mW/cm^2 for 0.5 to 24 hr, after which they were held in an incubator for 21 days to determine the consumption of sucrose syrup and to observe mortality. No significant differences were found between RFR-exposed and sham-exposed or control bees. In another study, Gary and Westerdahl (1981) found that foraging-experienced honeybees retained normal flight, orientation, and memory functions after exposure to 2.45-GHz CW RFR at power densities from 3-50 mW/cm^2 for 30 min.

Ground-Level Exposure—In the area outside the exclusion fence around the CRS transmit antennas, ground-level power densities would be below 0.1 mW/cm^2, which is incapable of producing substantial heating in living organisms. Thus, no adverse effects on plants or animals outside the exclusion fence is expected.

Within the exclusion fence, the time-averaged power density would exceed 1 mW/cm^2 within 1,550 ft in front of the CRS transmit antennas. The whole-body SAR resulting from RFR exposure within the exclusion area would depend on the body size and orientation of the animal. The highest power density, will be 258 mW/cm^2 and will be vertically polarized. An upright human would be parallel to the field polarization, increasing absorption of RFR. Most wildlife would have their body perpendicular to the electric field, reducing the absorption of RFR. Additionally, wildlife within the exclusion fence would be smaller than humans. Such animals would have resonant frequencies which are higher than for humans and thus more removed from the CRS's operational frequencies. Table 4.6.1 lists the maximum whole-body SARs inside the exclusion fence for a typical human, dog, rabbit, and mouse. As shown in that table, the maximum SAR for those animals would be much lower than for a person due to the smaller body size and horizontal orientation of the body. The maximum whole-body SARs would be 0.26 W/kg for a dog and less for a rabbit and a mouse.

Table 4.6.1
MAXIMUM WHOLE-BODY SARS FOR HUMANS AND WILDLIFE
IN THE CRS TRANSMIT EXCLUSION AREA

Entity	Whole-Body SAR* (W/kg)
Human (154 lb)	5.2
Beagle-sized dog (30 lb)	0.26
Rabbit (2.2 lb)	0.052
Large mouse (1 oz)	0.026

*Incident field 29 MHz, vertical polarization, 258 mW/cm^2.

Source: C.H. Durney et al., 1978.

The literature on RFR biological effects indicates that whole-body SARs associated with thresholds of potentially harmful effects occur in the range between 4 and 8 W/kg, and the threshold for human exposure set by AFOSH 161-9 and the 1982 ANSI standard is 0.4 W/kg. No effects on small animals inside the CRS exclusion fence from RFR would be expected even though such levels would be potentially harmful to humans.

4.6.3 Powerline Field Bioeffects

4.6.3.1 Overview

Electric power for the CRS transmit site will be conveyed via two new, separately routed, 115-kV powerlines. Each 115-kV line will be mounted on either a wood-pole H-frame or a standard monopole steel or concrete structure. The minimum width of the ROW for the powerlines will be 80 ft. Typical structure heights will be 55 ft for the H-frame and 95 ft for the monopole structure. Minimum ground clearance of the powerline conductors will be 22 ft. Maximum electric field strength at 3.3 ft agl at center span (conductor 22 ft above ground) will be 1.73 kV/m

beneath the line and 0.67 kV/m at the edge of the ROW for the H-frame powerline, and 2.01 kV/m beneath the line and 0.62 kV/m at the edge of the ROW for the monopole structure. Maximum magnetic field strength at 3.3 ft agl will be 172 milligauss (mG) at the center of the ROW and 46 mG at the edge of the ROW for the H-frame, and 164 mG beneath the line and 48 mG at the edge of the ROW for the monopole structures. North Dakota has a state limit of 9 Kv/m for the maximum electric field in the ROW. South Dakota has no limits. Neither state has any magnetic field restrictions.

The receive site will require much less power than the transmit site. It will be supplied by either a 7.2-kV or a 12.47-kV distribution (not transmission) line. (Distribution lines, which differ from transmission lines in many physical and engineering aspects, are used to bring power from substations to homes and business. Transmission lines carry significant amounts of power at much higher voltages from generating facilities to substations). The receive-site powerline would be mounted on normal wooden distribution poles. To reduce electrical noise interference at the receive site, the line will be buried in special underground power cables within at least half-mile of the receive site. Electric and magnetic fields at ground level from the aerial powerline would be considerably less than those from the transmit-site powerlines. A buried distribution line would create fields about one-tenth of those of aerial lines.

Recently, there has been increasing concern in the popular media about the possibility of potential health effects resulting from exposure to powerline electric and magnetic fields. As indicated above, the maximum electric field strength from the 115-kV transmit-site powerline would be well within the North Dakota state limit. Neither North Dakota nor South Dakota has a standard for magnetic field exposure. A review of effects reported in the scientific literature was carried out to determine the potential for human-health effects, if any, from these new powerlines and is summarized below.

4.6.3.2 Present State of Scientific Knowledge

Voltage on any wire produces an electric field in the area surrounding the wire. Powerline electric fields are characterized by the difference in voltage over a distance of one meter. In the case of the 115-kV transmit-site powerline described above, the maximum electric field in the ROW will not exceed 2.01 kV/m. A magnetic field is produced when electric current flows in a wire. The maximum magnetic field at the CRS transmit-site powerline ROW will not exceed 172 mG. For comparison, electric and magnetic fields created by wiring and appliances throughout the home are usually less than 0.01 kV/m and may reach a maximum of to 0.1 kV/m. Magnetic fields may be 40 mG at about 12 inches from a color television or electric kitchen range, but these fields rapidly decrease with distance from the appliance, becoming about 1 mG at distances of 3-5 feet.

Trees and building materials may greatly reduce the strength of powerline electric fields, but not of magnetic fields. Hence, powerlines can be the dominant source of magnetic fields in homes.

Hundreds of studies have been carried out over the past 20 years to investigate the potential health effects of exposure to powerline electric and magnetic fields. The physics of interaction of these fields with biological objects is well understood. Electric and magnetic fields induce weak currents and electric fields in people and animals. Their internal distribution and magnitude are complex functions of object shape, size, dielectric values, and orientation with respect to the external fields.

Several effects of 60-Hz electric and magnetic fields have been reported for laboratory animals. These include, e.g., a decrease in certain hormonal levels. However, these level also fluctuate under normal conditions and may not indicate an adverse health effect. Functional changes have also been seen in isolated cells and tissues. Some of these changes are the subject of scientific dispute, with their existence in question. Most of the claimed effects have been seen at relatively high electric field strengths of tens of kV/m, higher than levels that will result from CRS transmit-or receive-site powerlines. Since about 1979, a growing number of epidemiologic studies

have suggested that people who live or work near powerlines or with electrical equipment have a higher risk of cancer. Many of the studies have been questioned because of the inherent lack of knowledge of actual (versus estimated) exposures of the subjects, or because of methodological flaws. More than twenty epidemiologic studies are currently under way in attempts to resolve the disputes.

More than 20 reviews of the powerline bioeffects literature have been conducted since 1985. Most conclude that no link has been established between exposure to powerline fields and adverse human health effects. Several, however, strongly believe that such effects are possible, even probable. More research is needed before such assertions are scientifically supported.

There are no federal standards for exposure to 60-Hz electric or magnetic fields. However, requirements of the National Electrical Safety Code (NESC) for induced currents place some upper limits on powerline field strengths. The NESC requirements will be fully met in design, construction, and operation of the CRS transmit-site and receive-site powerlines. Seven states (Florida, Minnesota, Montana, New Jersey, New York, North Dakota, and Oregon) have issued standards limiting maximum electric fields either on the ROW or at the edge of the ROW. These standard range from 9-11 kV/m on the ROW, and from 1-3 kV/m at the edge of the ROW. The maximum electric field strength for the CRS transmit-site powerlines would be 2.01 kV/m within the ROW and 0.67 kV/m at the edge of the ROW, which would conform to the state standards. Two states, Florida and New York, have adopted maximum magnetic field standards at the edge of the ROW ranging between 100-150 mG. The maximum magnetic field for the CRS transmit-site powerlines will be 48 mG and will conform with those standards. The receive-site powerline will generate weaker electric and magnetic fields than the transmit-site powerlines and will conform with all state standards.

4.6.3.3 Conclusions

The 115-kV powerlines for the CRS transmit site and the 7.2-12.47 kV powerline for the CRS receive-site will meet existing North Dakota and NESC standards for maximum electrical and

magnetic field strengths within and at the boundary of the ROW. They will also conform to standards set by other states, although such standards are not applicable to the CRS powerlines. Based on a review of the biological effects literature, most scientific studies do not provide evidence that the CRS powerlines would pose a hazard to the health of human populations in the area. Certain studies claim effects of magnetic fields from powerlines in promoting cancer. Available scientific evidence is generally considered insufficient to support (or negate) those claims, and more definitive research is underway. Should those claims be proven true in the future, all powerlines in the United State would require measures to mitigate the hazard to human health. However, current evidence indicates that the likelihood of that occurring is remote.

4.6.4 Mitigation Measures

The measures listed below would minimize the potential for health effects on humans or wildlife. Measures M4.6.1, M4.6.2 and M4.6.5 are required to prevent significant impacts.

4.6.4.1 General Measures

M4.6.1— To prevent potentially harmful human exposure to RFR within the exclusion area, the perimeter fence at each transmit sector should be well maintained. The fence should be posted with signs to warn the public to avoid the exclusion zone.

M4.6.2— To prevent potentially harmful exposure of CRS workers to RFR, each employee at the transmit site should be briefed on the potential human health effects of RFR exposure at the initiation of employment. Safety regulations to prevent possible human exposure should be prominently posted at each equipment building and an Air Force employee should be designated the safety officer with responsibility for overseeing adherence to safety guidelines set forth in AFOSH 161-9, Exposure to Radio Frequency Radiation.

M4.6.3— To ensure human safety, the site safety officer should supervise all maintenance and security actions within the exclusion zones at transmit sectors.

M4.6.4— To verify the calculation of power density included in the Technical Report, power density at the exclusion fence boundary should be measured during system testing. If necessary, the fence should be relocated to maintain power densities below the appropriate standard for human exposure. (Measurements at the ECRS have shown that the calculations of power density from OTH-B radar systems are accurate. Thus it is considered very unlikely that movement of the exclusion fence will be necessary.)

4.6.4.2 Measures Applicable to Powerlines

M4.6.5— To minimize hazards to the public from exposure to powerline conductors and electromagnetic fields generated by powerlines, design and construct the powerlines for the CRS transmit and receive sites in accordance with the National Electric Safety Code. Instruct landowners affected by the right-of-way for CRS powerlines about safety precautions for activities near powerlines.

4.7 BIOTIC RESOURCES

This section is based upon the technical reports on vegetation, wetlands and aquatics, mammalian studies, avian studies, threatened and endangered species, and powerline biological resources prepared by Metcalf & Eddy/Homes & Narver (1990E, 1990F, 1990G, 1990H, 1990I, and 1990J).

4.7.1 Transmit Site

4.7.1.1 Vegetation

The CRS transmit facilities will affect about 2,000 acres, approximately 1,500 acres of which will be within the exclusion area. In the exclusion area, land now farmed will be planted with grass; taller trees may be removed from the remainder. Vegetation will be stripped from 504-511 acres to prepare for construction of access roads, perimeter roads, buildings, the antenna and groundscreen, and the out-of-coverage sounder antennas. Fires will be suppressed and grazing by

livestock and wildlife prohibited after CRS construction, resulting in the buildup of plant litter and possibly changes in vegetation over the long term.

Tx-N—Construction at Tx-N would enclose but not physically alter 1,336 acres of native rangeland, 18 acres of forest, and 179 acres of wetlands. No cropland would be affected. Construction of the antenna facilities would directly disturb 438 acres of native rangelands, 62 acres of wetlands, and 10 acres of other vegetation that are wholly within the Hecla sandhills region.

Construction activities at the Tx-N preliminary site layout would not destroy the designated native prairie in the northern CSA, but that prairie would be within the buffer zone. Because prairie resources have not been thoroughly investigated in this part of South Dakota, the significance of fencing and fire-suppression within the buffer zone is not well understood, but CRS could reduce the value of the prairie. Native prairie is a rare vegetation type within South Dakota and also potential habitat for the federally listed Western fringed prairie orchid.

CRS construction would affect 91 acres of designated prime farmland and land that would be prime farmland if drained that is currently used for grazing. Of these 91 acres, 10 would be permanently lost due to construction of foundations and buildings, and 34 would be degraded by gravel surfacing but might be available for agricultural use when the CRS is decommissioned. The other 46 acres would be removed from agricultural production for the duration of the project but would be available for agricultural use with no alteration in productivity after decommissioning.

Tx-S—Construction at Tx-S would disturb 440 acres of croplands, 34 acres of grasslands, 5 acres of woodland, 23 acres of wetlands, and 2 acres of other vegetation. The grasslands are small parcels of native grassland, and the woodlands are planted stands. The area within the exclusion fence, which would not be physically disturbed, includes 1,206 acres of cropland, 49 acres of grassland, 8 acres of woodland, 257 acres of wetlands, and 8 acres of other vegetation. Wetlands in the exclusion area include farmed temporary wetlands (215 acres); farmed,seasonal wetlands (35 acres); and about 7 acres of unfarmed wetlands. About 23 acres of wetlands would be filled. Of

this acreage, 22 acres are farmed temporary wetlands, and about 1 acre is semipermanent or unfarmed temporary and seasonal wetlands. Impacts on designated prime farmlands and designated farmlands of statewide importance would include the permanent loss of 51 acres due to building construction, 11 of them prime; the degradation due to gravel emplacement of 89 acres, 20 of them prime; and the loss of the use of 694 acres for the life of the project.

4.7.1.2 Wetlands

Construction of the CRS transmit facilities will effect wetlands through filling, alteration of the hydrologic regime, removal of trees, and restriction on wildlife accessibility. Wetland filling will require a permit from the U.S. Corps of Engineers under Section 404 of the Clean Water Act. The effect of wastewater disposal will be minimal if state regulations for design of sanitary systems are followed. Groundwater wells will draw from 150 ft or more below the surface and therefore will not affect seepage into wetlands. Hydrologic changes are discussed in Section 4.2.1 and wildlife impacts are discussed in Section 4.7.1.3. Significant impacts on wetlands are expected to be confined to the area enclosed by fencing. Wetlands in the buffer zones around the preliminary site layout will be affected only if changes in the final design cause a shift in the layout that brings portions of these wetlands into the exclusion area.

Tx-N—CRS construction at Tx-N would result in the filling 137 emergent-type wetlands covering 62 acres, including 46 acres of seasonal, 9 acres of temporary, and 7 acres of semipermanent wetlands. The filled wetlands would be 5.8% of the 1,068 acres of wetlands in the CSA and 1.1% of the 5,792 acres of wetlands in the transmit study area. A total of 241 acres (12%) of the preliminary site layout area are wetlands; 179 acres would be in the exclusion area but would not be physically disturbed. Eighty-four percent of that acreage would be seasonal wetlands, 9% temporarily flooded wetlands, and 6% semipermanently flooded wetlands. An additional 334 acres of wetlands in the buffer zone adjacent to the site, 89% of which are seasonal, could be affected construction if the preliminary site layout were changed during final design. Alteration of seasonal wetland would affect associated functional values, including reduction in

flood-storage and sediment retention capacity, decreased groundwater recharge, and loss of wildlife habitat. Most of those seasonally-flooded wetlands are used as breeding habitat by ducks and as food and water sources by other wildlife. Minimal impacts on aquatic wildlife would result because very little aquatic habitat exists in the study area.

Tx-S—Construction at Tx-S would require filling 23 acres and fencing an additional 257 acres of wetlands. The 23 acres of filled wetlands would be 1.9% of the 1,191 acres of wetlands in the CSA and 0.4% of the wetlands in the transmit study area. Another 241 acres of wetlands in the buffer zone could be affected if the site layout were adjusted during final design. Most of the affected wetlands would be farmed, temporarily-flooded wetlands of value to migrating wildlife, but whose long-term wildlife value is diminished by farming. Birds and small mammals would still have access to the enclosed wetlands. Because all wetlands in this CSA that would be affected are either temporarily flooded or farmed or both, enclosure within the exclusion area probably would increase the habitat value to birds by precluding farming of the wetlands. Aquatic impacts would be minimal because very little aquatic habitat occurs in this CSA. Hydrologic impacts would include loss of flood-storage capacity and decreased sediment retention capacity.

4.7.1.3 Mammals

Impacts on mammalian populations will not be significant. Loss of wetland habitat, the principal impact on deer, will be offset by mitigation for the wetlands impacts. Few pronghorn are present; impacts will be minor. Interference with animal movements will also be minor. The somewhat higher risk of road kills of deer and pronghorn during construction will not be significant because construction vehicles are noisy and visibility will generally be good. During operation, the traffic increase will be small, and the risk of road kills will be low.

Tx-N—Winter habitat is most abundant in the southwestern quarter of the northern transmit CSA, where wetlands provide winter habitat. The Tx-N preliminary site layout avoids that area, minimizing impacts on deer, but 234 acres of palustrine-emergent wetlands and 18 acres of woodland that could serve as wintering areas would be enclosed by the exclusion fence and

therefore be unavailable to deer. Moreover, because the buffer area contains a higher proportion of wetlands than the preliminary site layout, the enclosed wetland acreage could increase if the antenna position is shifted during final design. Antennas shifts within the buffer zone would not alter the amount of woodland lost. Because deer disperse in all directions from their wintering grounds, few deer would be forced out of normal travel paths to circumvent the perimeter fence.

Tx-S—White-tail deer populations are low in the southern transmit CSA because of a lack of winter habitat. The agricultural land in the CSA could provide food for deer moving through the area in winter, but food is also abundant outside the CSA. About 282 acres of wetlands and 4 acres of woodlands within Tx-S would be affected; the wetlands are typically farmed and lack the thick marsh vegetation needed for good winter habitat for deer. Shifts in the site layout within the buffer zone would not change the amount of either wetlands or woodlands affected. The loss of winter habitat would not be significant.

Summer habitat for deer is plentiful in the southern CSA because agricultural crops provide abundant food sources. The project would not significantly alter the amount of this habitat regionally, and no significant impacts on deer populations are expected.

4.7.1.4 Birds

Birds will be affected by loss of habitat and by collisions with the CRS antennas. The most important impact on habitat will be the loss of display grounds (leks), nesting sites, and wetlands suitable for resting or staging during migration. However, the most important impact on bird populations will be the potential for collisions with the antennas. Collisions can occur when visibility is good, but are more likely during poor weather and at night when visibility is poor. Waterfowl strikes are probable during the spring, when heavy precipitation is most frequent and the availability of open water would attract birds, leading to frequent low-level local movements. Waterfowl collision risks may also be high in the fall because waterfowl are numerous and often fly low between feeding and resting areas. Strikes by migratory birds are likely to occur throughout the life of the project.

The risk of collision is greatest for swans, shorebirds, and geese and for species that frequently migrate at night, particularly ducks, some water birds (rails and coots), and passerines. The collision potential for raptors, sandhill cranes, and some water birds is relatively low because they migrate mainly by day. The potential for gamebird collisions would also be low because they primarily make local daytime flights. Raptors, especially species that forage on roadkills; passerines; and gamebirds could be struck by project vehicles.

Raptors are extremely maneuverable in flight, have excellent vision, and migrate mainly during good weather. Moreover, except for owls, raptors are mainly active by day. Collision with man-made objects is uncommon for raptors, although collisions appear to be more probable when the bird is foraging.

Game birds are not migratory, generally fly infrequently, and then only for short distances, but are not agile flyers. Local birds could probably acclimate to the CRS antennas, reducing the risk.

Passerines frequently collide with tall structures and the frequencies of collision are generally proportional to the heights of the structures. Because these birds are small and exceptionally agile, significant numbers of daytime collisions are not expected. However, mass collisions may occur at night or during inclement weather. A consistent chronic rate of collisions is also expected. Additionally, the portion of the antenna backscreen above 75 ft agl would be sufficiently open to present reduced obstruction.

Water birds include species that are almost exclusively nocturnal migrants and frequently collide with man-made structures (rails and coots), but most migrate during either day or night (gulls). These species are not strong fliers and often fly at low altitudes. High numbers of rails and coots, low to moderate numbers of gulls, and relatively low numbers of other waterbird species can be expected to collide with the antenna backscreens.

Shorebirds will also be at risk because of the frequency with which they fly during rain or darkness when visibility is low. The scarcity of suitable habitat, however, suggest a low probability of collision except in wetter years when moderate numbers of kills may result.

Sandhill cranes are primarily diurnal migrants that fly at high altitudes, although they are known to collide with power lines and other objects. Few sandhill cranes appear to be present in the study and area, therefore, the potential for effects on the species is low.

Swans were not frequently observed in the study area, but a major swan migration corridor crosses northeastern South Dakota, and numerous swans may pass through the study area in some years. Large numbers of tundra swans were heard on some evenings during the 1987 observations. Moreover, swans often fly in poor weather, especially in the fall. Thus moderate to large numbers of swans could collide with the transmit antenna in some years, although small numbers are expected in most years.

Geese are the most numerous birds observed in the study area and often fly in large flocks. Moreover, geese often migrate during poor weather, increasing the risk of multiple strikes. Thus, multiple strikes are possible even though migratory movements of geese were generally observed flying above 150 ft above ground level (agl) during the day, and appear to have been far higher at night. Local movements at dawn and dusk are often at relatively low altitudes and could make the collision risk higher.

Ducks are largely nocturnal migrants and frequently collide with power lines and other man-made objects. They stage in moderate to large numbers near the study area, with large concentrations on or near both transmit CSAs. Although night flights were higher than day flights during the periods of peak migration, low-level flights were observed. The risk of a substantial number of collisions is relatively high, particularly during wet years.

The risks of collisions would be greater at Tx-N than at Tx-S during most years for most species groups because there are more wetlands at Tx-N. The relative risk would be reversed in unusually wet years for some species groups when extensive flooding occurs near Tx-S.

No habitat of good quality for woodland raptors and passerines would be lost at either transmit CSA. The quality of native rangeland with respect to ground-nesting passerines and raptors may actually improve as a result of the elimination of grazing on rangelands enclosed by the exclusion fence, but not covered by fill.

Habitat losses at Tx-N would include destruction or displacement of one sharp-tailed grouse and one greater prairie chicken lek and the destruction of 7 acres of semipermanent, 46 acres of seasonal, and 9 acres of temporary wetlands, all of which are breeding habitat for ducks and other wetland species. In addition, 438 acres of native grassland habitat would be destroyed. An additional 179 acres of wetland and 1,336 acres of native upland grassland would be enclosed by the exclusion fence. Because no sure method exists for creating new leks , the effect of the loss of the existing leks on the breeding success of the local populations of the sharp-tailed grouse and greater prairie chicken is uncertain and may be significant.

Loss of wetland habitat would primarily affect dabbling ducks that use seasonal wetlands for nesting in all but the driest years. Diving ducks and geese, which use semipermanent or permanent wetlands, and water birds and shorebirds are unlikely to use these wetlands in large numbers.

Disturbance of breeding birds by noise may reduce habitat value during the construction period, but operation of the facility should have little such effect. This short-term impact would be greater at Tx-N than at Tx-S because more suitable breeding habitat is available to attract more breeding pairs of birds.

Little habitat of value to breeding birds would be lost at Tx-S. No known leks would be lost, and virtually all the wetlands lost would be temporary wetlands suitable for staging during migration but of low value to breeding birds. Less than 1 acre each of semipermanent and seasonal wetlands that are useful for breeding, 22 acres of temporary wetlands useful for staging, and 34 acres of native grassland useful for breeding of upland birds would be lost. Another 220 acres of temporary, 35 acres of seasonal, and 2 acres of semipermanent wetland and 49 acres of native

grassland would be enclosed by the exclusion fence. Little disturbance of breeding birds would be caused by noise during the construction period because of the scarcity of nearby breeding habitat.

4.7.1.5 Threatened and Endangered Species

Migrating bald eagles may collide with the CRS transmit antennas during periods of low visibility, but collisions are expected to be uncommon because migration rates of raptors are generally low when visibility is poor. Risks, though low, would be higher at Tx-S during wet years when more wetlands and potential prey are available. Risks probably would be higher at Tx-N in other years. No critical eagle habitat will be affected. The Air Force has determined that possible effects on bald eagles may result from the CRS and has requested an biological opinion from the USFWS under the Endangered Species Act.

Peregrine falcons would be at risk of collision primarily during pursuit of prey, but would not be significantly affected because the number of peregrines in the study area is extremely low. Only two individuals, both migrants, were seen. The Air Force has determined that possible effects on peregrine falcons may result from the CRS and has requested a biological opinion from USFWS under the Endangered Species Act.

Few ospreys migrate through the transmit study area, and any effects from collisions would not significantly impact the regional populations. Significant habitat for ospreys is absent from the study area in most years.

Buff-breasted sandpipers are uncommon and migrate at very high altitudes, and therefore collide less frequently with towers than do passerines. The habitat that will be lost is useful to migrating buff-breasted sandpipers, but it is locally abundant. Therefore, the loss will not significantly affect the population of this species.

The piping plover and the whooping crane do not occur at either alternative site and no effects on those species are expected. However, the USFWS is preparing a biological opinion on possible effects from CRS on those species. The presence of the burying beetle or the Western

prairie fringed orchid at either site layout is uncertain. Field studies are planned during summer 1990 to determine the presence or absence of those species.

4.7.2 Receive Site

4.7.2.1 Vegetation

The receive facilities will affect 527 acres through construction of roads, buildings, antennas, and groundscreens. The area disturbed will be about the same as at the trans... site, but the amount of land enclosed within the exclusion fence at the receive site will be much smaller.

Rx-E—Construction at Rx-E would disturb 267 acres of cropland, 245 acres of native grasslands, and 15 acres of wetlands. None of the grasslands is native. A total of 463 acres of designated prime farmland and designated farmlands of statewide importance would be removed from agricultural use. Construction of buildings and roads would permanently affect 123 acres of designated prime farmland and 2 acres of designated lands of statewide importance. Gravel surfacing would degrade, but not permanently remove from use, 331 acres designated as prime farmland and 7 acres designated as farmland of statewide importance.

Rx-W—Construction at Rx-W would remove 447 acres of cropland, 75 acres of grassland, 1 acre of woodland, and 4 acres of wetlands. No native vegetation other than the wetlands would be affected. Virtually all of the cropland (94%) is planted to small grains. No designated lands of statewide importance would be affected, but 85 acres of designated prime farmland would be permanently affected by construction and temporary impacts due to emplacement of gravel would affect another 232 acres.

4.7.2.2 Wetlands

Wetlands will be affected by filling, alteration of the hydrologic regime, removal of trees, and restriction on wildlife and cattle accessibility. Wetland filling will require a permit from the U.S. Army Corps of Engineers under Section 404 of the Clean Water Act. The effects of wastewater

disposal will be minimal, and the development of a water supply for the facility is not expected to affect wetlands. Hydrologic changes are discussed in Subsection 4.2.3, tree removal is discussed in Section 4.7.2.1, and the impacts of wildlife exclusion are discussed in Section 4.7.2.3. The potential for impacts on lands in buffer zones is discussed in Section 4.7.1.2.

Rx-E—Construction at Rx-E would affect 16 wetlands covering 15 acres, mainly temporary wetlands that are now farmed (8 acres) and scrub-shrub with saturated soils (6 acres). The filled wetlands would be 1.4% of the 1,046 acres of wetlands in the CSA and 0.2% of the 6,126 acres of wetlands in the receive study area. Shifting of the site layout within the buffer zone would not significantly change the area of wetlands affected. Construction of CRS at this site would decrease wetlands functional values, including flood storage, sediment retention, and wildlife habitat. Most of the wetlands are dominated by mixed palustrine emergent/scrub-shrub vegetation that provides cover and forage for mammals. Potential aquatic impacts would include increased stream turbidity and sedimentation and accelerated soil erosion.

Rx-W—Construction at Rx-W would result in the filling of 19 wetlands covering an area of 4 acres. Virtually all of these emergent-type wetlands are farmed, drained, temporary, or a combination of these types of wetlands. Less than 1 acre of the filled wetlands would be seasonally flooded and none would be of the semipermanently or permanently flooded type. The filled wetlands would be 0.8% of the 479 acres of wetlands in the CSA and 0.1% of the 6,126 acres of wetlands in the receive study area. Modification of the site layout within the buffer zone would not significantly alter the area of wetlands affected. The 4 acres of wetlands affected have limited wildlife value because of farming use. Minimal aquatic impacts are expected, because few aquatic habitats occur in the study area. The loss of 4 acres of wetlands will not significantly affect the local hydrological and biologic functional values of wetlands.

4.7.2.3 Mammals

Loss of wetland habitat, the principal source of impact on deer and moose will be offset by replacement of the wetland value. Interference with animal movements and increases in the number of road kills will not be significant. Losses of summer habitat for deer will not be significant at either CSA. Impacts on mammalian populations are not expected to be significant.

Rx-E—Winter habitat for deer occurs along the eastern edge of Rx-E and is adjacent to an extensive area of woodland and wetland habitat valuable for both deer and moose. The Rx-E layout would not affect that area. Nonetheless, an estimated 15 acres of either palustrine emergent wetlands, palustrine shrub/scrub wetlands, or wetlands intermediate between these two would be lost. Because deer and moose primarily use forests for winter habitat in Minnesota and no forest cover would be lost, the loss of wetland winter cover would be small. Slightly greater losses could occur, including minor losses of forest cover, if the antennas were shifted during final design, but the overall impacts would not be significant.

Rx-W—The proposed preliminary site layout at Rx-W would not affect winter habitat for deer and moose in the western part of the CSA. About 1 acre of planted woodland and 5 acres of wetlands would be lost. If the site layout were shifted during final design, up to 2 more acres of forested wetlands could be lost.

4.7.2.4 Birds

Birds will be affected by habitat loss and by collisions with the CRS receive antennas. The most significant habitat losses will be that of display grounds (leks), nesting sites, and wetlands suitable for resting or staging during migration. Little breeding habitat for woodland raptors and passerines will be lost. Disturbance of breeding birds by noise could reduce habitat value during the construction period, but operation of the facility should have little such effect.

Collision losses would be a more significant impact than habitat destruction. The number of birds collisions with the receive antennas should be few when visibility is good, but could be significant during poor weather and at night when visibility is poor. The discussions of these risks for raptors and game birds at the transmit site in Section 4.7.1.4 are applicable to the receive site as well, and impacts on these two types of birds are expected to be low.

The potential for impacts on passerines is high because they make low-level nighttime migratory flights. Daytime collisions would be unlikely because of the bird's small size and flight agility.

Waterbirds of most species are not expected to be significantly affected, although moderate numbers of rails and coots and occasional herons and gulls could collide with the antenna.

Shorebirds were seen in small to moderate numbers and are consequently not likely to collide with the antenna in significant numbers. The collision risk for this group is slightly higher at Rx-W than at Rx-E.

Although they tend to fly above 100 ft and in good weather, sandhill cranes are expected to collide in low to moderate numbers with the antennas during low-level, local movements.

The collision risk for swans is uncertain because many of the swans passing through the area may have done so at night, when they could not be identified during the avian studies. Based on daytime observations, impacts are expected to be low to moderate, but depending on night flight patterns, risks may be higher then. Rx-W poses greater risk than Rx-E.

Geese move through the study area in large flocks, but they tend to fly high enough that the risk of collision is relatively low. Only low to moderate numbers of collisions are expected. However, mass kills are possible.

Moderate numbers of ducks stage and nest in the area, and a moderate number of collisions are expected.

Overall, the risks of collisions with the antenna is roughly the same at the two receive site layouts. Collisions of migratory birds will likely occur throughout the life of the project, with a higher probability of multiple kills during periods of poor visibility.

Rx-E—Habitat losses would include the loss or displacement of a sharp-tailed grouse lek and destruction of wetlands. The lek may be destroyed, but this is not expected to have a severe effect because some relocation of leks occurs naturally from year to year. The lack of a sure method to create a new lek essentially precludes mitigating any impact on local populations of sharp-tailed grouse. Fewer than 2 acres of seasonal and about 8 acres of temporary wetland would be lost. An estimated 11 acres of additional seasonal wetland and 26 acres of additional temporary wetland would be enclosed by the exclusion fence. About 6 acres of scrub-shrub wetlands would be filled, and another 43 acres would be enclosed but not filled. No native grassland would be enclosed.

Rx-W—Rx-W would not affect habitat of value to breeding birds. No known leks would be affected, and virtually all the filled wetlands would be temporary wetlands suitable for staging during migration, but of low value to breeding birds. Fewer than 2 acres of seasonal and fewer than 3 acres of temporary wetlands would be filled. About 1 acre of woodland habitat for raptors and passerines would be lost. The exclusion fence would enclose about 14 acres of temporary, 5 acres of seasonal, and 1 acre of semipermanent wetlands. No native grasslands would be enclosed.

4.7.2.5 Threatened and Endangered Species

Bald eagles and peregrine falcons may be affected for reasons given in Subsection 4.7.1.5. The Air Force has requested a biological opinion under the Endangered Species Act from the USFWS concerning possible effects on those species from the CRS.

The grey wolf will not be affected because Rx-E and Rx-W are outside the area designated as peripheral range of the grey wolf. Moreover, the study area contains little suitable habitat.

Likewise, no piping plovers were seen at the receive study area during avian surveys of 1987, 1988 and 1989. No effects on those species are expected.

Impacts on state-listed bird species will not be significant because these species are only occasional or accidental migrants through the study area.

Impacts on the federally and state-listed species that may be in the study area but have not yet been observed (see Table 3.6.6) depend on their abundance and distribution—factors that cannot be assessed with available information. Suitable habitat for those species, however, is more abundant at Rx-E than at Rx-W. The preliminary site layout would disturb 75 acres of upland grassland and 5 acres of wetland at Rx-W and 245 acres of upland grassland and 17 acres of wetland at Rx-E. Moreover, the most probable location for any of these species is at or near the beach ridges of glacial Lake Agassiz at Rx-E.

4.7.3 Power Supply

4.7.3.1 Impact Overview

Potential impacts biological resources result primarily from physical disturbance during powerline construction and substation expansion. Those impacts will be temporary, but most severe if construction occurs in the spring when wetlands are at maximum size, soil is saturated, plants are sprouting, and wildlife are raising their offspring.

4.7.3.2 Transmit Site

Vegetation—Vegetation removal and soil disturbance will occur at the powerline structures locations and the Groton and Forman substations, during tower erection, stringing of conductors, heavy equipment movement, and trips to each tower site by delivery trucks. The areas that would be affected at each link are shown in Table 4.1.1.

Impacts on vegetation will generally be temporary because native grasses and forbs will probably reestablish during the subsequent growing season. The transmission structure will

eliminate a small amount of farmland. In forested areas and at shelterbelts, the ROW would be cleared and possibly treated with herbicides to reduce regrowth.

Link 7 has the highest potential for disturbing native vegetation. However, impacts would be temporary and revegetation should occur during the next growing season. Impacts could also be minimized by using existing ROWs as much as is feasible.

Wetlands—Construction at the structure sites could affect wetlands that are present. In general, the corridors with the highest percentages of wetland acreage have the greatest potential for impacts. Impacts on semi-permanent and seasonal wetlands would be more significant than disturbance of temporary wetlands. Because most wetlands of the powerline study area are seasonal, semi-permanent, or temporary, wetland impacts could be minimized by scheduling construction to avoid the spring/early summer wet season.

Mammals—Powerline construction activities could cause direct and indirect impacts on mammals. Direct impact include road kills and destruction of small mammals by heavy equipment. Construction will occur during daylight hours, reducing the likelihood of road strikes. Given the relatively small number of vehicle trips required, road kills will be a minor impact.

Habitat disturbance will be the major indirect impact on mammals. Construction activities could destroy the dens of ground-dwelling mammals in native rangeland and pasture, particularly in Links 5,7, and 8. But because of the abundance of similar habitat, that impact will be minor.

Birds—Possible powerline impacts on birds include habitat loss and collision and electrocution hazards. At each transmission structure and at the Groton and Forman substation expansions, installation of poles and equipment during powerline construction would destroy small areas of habitat. Tree clearing could remove some of the more valuable habitat in the area. However, the powerline will not cross any large forested areas, and tree removal will occur only where the powerline crosses shelterbelts and woodlots. Because those features are widely scattered in the region, route selection could effectively minimize the number of trees removed. It is likely that construction of the transmission structures and substation expansions will probably

occur mostly on grasslands. That habitat is widely abundant in the area and removal of several acres will be insignificant. Poles and conductors provide perching habitat for many bird species.

Numerous bird species are known to collide with aerial powerlines. Waterfowl, rails, coots, gulls, grebes, and shorebirds are reported to suffer the highest mortality rates. Passerines, doves, woodpeckers, and raptors are thought to have lower collision risks because they are more agile flyers. Studies of bird behavior indicate that the most common reaction is to fly over the line. In the H-frame configuration, the three conductors are in a horizontal plane, while in the monopole design the three conductors are at different elevations. Because the monopole conductors occupy more vertical air space, the collision hazard is expected to be greater.

Powerline heights will range up to 55 ft agl for H-frames and up to 95 ft agl for monopoles, which are lower than the maximum height of 135 ft for the transmit antennas. Because the powerline conductors will be lower and will occupy much less airspace than the CRS antennas, the collision hazard will be much lower for the powerlines than that for the antennas. Collisions would be most likely during low-level local movements, particularly during periods of low visibility.

Waterbirds are reported to collide with powerlines frequently. Temporary wetlands attract fewer birds for shorter periods than seasonal and semi-permanent wetlands. In addition, seasonal and semi-permanent wetlands tend to support breeding populations with young birds, which are weak flyers. Thus, the amount and type of wetlands and its proximity to the powerlines are important indicators of collision risks.

Links 1, in conjunction with link 3, could connect the Groton substation to Tx-S. Link 1 contains more of wetlands and a higher percentage of seasonal and semi-permanent wetlands. Therefore the collision risk is lower for Link 2 than for Link 1.

Links 7, 8, and 9, when combined with some combination of the shorter Links 5, 6, and 10, would connect Forman to Tx-N. Link 7 has the highest wetland density and the highest percentage of seasonal and semi-permanent wetlands, thus, it poses the greatest collision risk. Links 8 and 9

have similar wetlands densities. However link 8 is shorter and for that reason would present a lower collision risk.

Large birds could be electrocuted if they touch two conductors or a conductor and a grounded structure simultaneously. Raptors that use transmission structures as hunting perches or resting spots are at greatest risk. To minimize that risk, powerline conductors will be spaced at distances that exceed the wingspans of most raptors, as recommended by guidelines of the Raptor Research Foundation. Thus the electrocution risk to raptors and other large birds will be small.

Threatened and Endangered Species—Possible effects on federally listed species include electrocution, collisions, vehicle strikes, and habitat loss. As described above the transmit-site powerlines would be designed to minimize the electrocution hazard. The collision risk for the listed bird species is expected to be low. Construction will occur during daylight hours, and road strikes by construction vehicles are not expected. The destruction of bald eagle or peregrine falcon habitat is very unlikely. Destruction of a Western prairie fringed orchid plant or colony could occur during construction, but that impact could be prevented by conducting surveys for the plant prior to powerline construction and rerouting the powerline or relocating structures to avoid the plants. No effects on threatened and endangered species, except the bald eagle, the peregrine falcon, the western prairie fringed orchid, and the burying beetle, are expected. The Air Force has requested a biological opinion from the USFWS concerning the bald eagle and the peregrine falcon, Field surveys are planned to determine the presence or absence of the orchid or beetle.

4.7.3.3 Receive Site

Vegetation—The area of soil disturbance and vegetation clearing for each powerline corridor is given in Table 4.1.2. The disturbed areas would be much greater for a completely underground than for an aerial powerline. Nevertheless the disturbed area could be revegetated after construction is complete. For an aerial line, only the small area at the base of the powerline poles would be permanently affected. If the line is completely underground, no permanent vegetation effects would result.

Most of the area in each corridor is cultivated and the major vegetation impact will be loss of farmland. For an aerial line, the total area of farmland removed from production would be about 1.8 acres for the Rx-E powerline or about 0.9 acre for the Rx-W powerline. If the powerline is placed completely underground, no farmland would be lost.

Wetlands—Equipment movement and pole installation would crush and destroy wetland vegetation. The area disturbed would be much greater for an underground line than for an aerial line (see Table 4.1.2). For the Rx-E powerline, the total area disturbed would be about 1.8 acres for an aerial powerline and about 24-27 acres for a completely underground powerline. For Rx-W, an aerial line would disturb 1.20 acres and an underground line would disturb about 9 acres. If the percentage of wetlands area disturbed is the same as the wetland percentage occurring in each corridor, the area of disturbed wetland would be as shown in Table 4.7.1. At either Rx-E or Rx-W, construction of an aerial powerline would affect less than 0.10 acre of wetland and construction of a completely underground line would affect less than 1.5 acre.

Table 4.7.1
POSSIBLE AREA OF WETLAND DISTURBANCE, RECEIVE-SITE POWERLINE CORRIDORS

Corridor	Disturbed Area (acres) Aerial Line	Disturbed Area (acres) Underground Line	Wetland Disturbance (acres)[a] Aerial Line	Wetland Disturbance (acres)[a] Underground Line
Dakota Junction - Rx-E	1.76	24.11	0.06	0.80
Morris Owen - Rx-E (North line)	1.77	24.32	0.10	1.36
Morris Owen - Rx-E (South line)	1.87	27.11	0.09	1.33
Radium - Rx-W	1.20	8.95	0.02	0.13

a Assumes wetland percentage of disturbed area is the same as wetland percentage for entire corridor.

SOURCE: SRI International

Mammals—As described above for the transmit-site powerlines, potential impacts on mammals include habitat disturbance, road kills, and electrocution of small mammals that climb powerline poles. None of those impacts is expected to significantly affect the local population of mammals.

Birds—As discussed above for the transmit-site powerlines, possible impacts on birds include habitat loss and collision and electrocution hazards. Construction will affect small areas of farmland, grassland, and possibly wetlands and woodlands. The total area affected would be 1-9 acres. No significant effect on habitat availability would result.

Aerial powerlines for the receive site will be supported on poles up to 45 ft tall. Three conductors spaced at 3.5-ft intervals will be mounted on a wooden crosspiece. The conductors will be small diameter, which reduces it visibility and increases the collision hazard. While some birds will collide with the powerline, no significant impacts on regional bird populations are expected. There would be no collision hazard for an underground powerline.

The proposed aerial powerline would have conductors spaced at distances less than the wingspan of large raptors, such as bald eagles. Most documented raptor electrocutions occur at low-voltage distribution lines, such as are proposed for the CRS receive site. Therefore there is potential for electrocution of raptors with the currently proposed design. That hazard could be eliminated by designing the powerline to maximize the distance between conductors. There would be no electrocution potential with a completely underground powerline.

Threatened and Endangered Species—Electrocution and collision are the most significant hazards to the federally listed bald eagle and peregrine falcon. Both hazards are described above. Raptor electrocutions and collisions could occur if an aerial line is constructed. The bald eagle has a large wingspan and may be somewhat susceptible to electrocution or to collision with the powerline. Loss of bird habitat will be insignificant.

No impacts on the piping plover or the gray wolf are expected because they apparently do not occur in the study area.

4.7.4 Mitigation Measures

Measures that would be used to minimize the effects of the construction of the OTH-B CRS on the biotic resources of the transmit and receive CSAs are listed below. Measures M4.7.2, M4.7.3, M4.7.4, M4.7.9, M4.7.10, M4.7.12, and M4.7.13 are required to prevent significant impacts.

4.7.4.1 General Measures

M4.7.1 - To mitigate effects on native prairie and upland areas, reseed areas acquired but not used for construction and disturbed portions of the exclusion area with native prairie species, and manage the areas to protect native species.

M4.7.2 - To prevent impacts to the threatened Western fringed prairie orchid, conduct site surveys for that plant prior to construction. If the species is found, additional mitigation may be required.

M4.7.3 - To minimize effects on wetlands, avoid wetlands during siting of CRS support facilities such as fuel and water storage tanks, wastewater disposal systems, and electric substations.

M4.7.4 - To comply with the national objective of no net loss of wetlands, the Air Force will consult with the U.S. Army Corps of Engineers and the USFWS to determine plans to replace the functional value of disturbed wetlands on an acre-for-acre basis. The Air Force will employ on- or off-site restoration, creation, or expansion of wetlands or will contribute to governmental or private programs that restore or create wetlands. A permit for filling of wetlands will be required from the U.S. Army Corps of Engineers under Section 404 of the Clean Water Act. Mitigation requirements will be included in that permit.

M4.7.5 - To avoid disturbing wetlands, build wastewater disposal systems where they will not physically or hydraulically affect wetlands.

M4.7.6 - To compensate for bird collisions, the Air Force will create, develop, or provide funds for a 700-acre avian compensation area more than five miles from the transmit site. The area will contain palustrine emergent wetlands and uplands grasslands. The Air Force will purchase the property and will turn over the ar a to either USFWS or the state wildlife agency.

M4.7.7 - To prevent construction impacts on known nesting and breeding areas, place fencing around those locations at the sites but outside facility footprints prior to the start of construction.

M4.7.8 - To monitor the effectiveness of mitigation measures for bird strikes, develop and implement a program to record bird kills at the antenna sites in conjunction with USFWS and state wildlife agencies.

4.7.4.2 Applicable to CRS Powerlines

M4.7.9 - To minimize impacts on sensitive habitat, consult with USFWS and state wildlife agencies to identify and avoid such areas during powerline route selection. Survey for threatened and endangered species along the selected route, and realign the route to avoid areas important to listed species.

M4.7.10 - To increase the visibility of powerlines and reduce the potential for bird collisions, install marker balls on powerlines at high-risk locations identified through consultation with USFWS and state wildlife agencies. In addition, select routes that avoid wetlands and major avian flight paths between wetlands and foraging areas.

M4.7.11 - To minimize withdrawal of farmland from production, route the powerlines along existing ROWs, section lines, property boundaries, and field boundaries. Allow normal farming activities within the ROW after powerline construction is complete.

M4.7.12 - To reduce impacts on wetlands, transmission structures should be shifted outside wetlands by varying span lengths as necessary. When wetlands cannot be avoided, keep the area affected by heavy equipment travel to a minimum. Replant disturbed areas with the vegetation growing prior to construction.

M4.7.13 - To reduce the electrocution hazard to raptors, design powerlines in accordance with guidelines developed by the Raptor Research Foundation and install perch guards on aerial powerlines serving the receive site.

4.8 AESTHETICS (VISUAL IMPACT)

4.8.1 Overview

Visual impacts are analyzed in this section using a modified version of methodology developed by the U.S. Bureau of Land Management Visual Resource Management Program. (U.S. Bureau of Land Management, 1986) The assessment of visual impacts is based on determining if visual changes caused by the construction or operation of the CRS will significantly change or contrast with the dominant features of the existing landscape when viewed from selected vantage points. Scenic quality and viewer sensitivity are key factors in visual impacts assessment.

The assessment was conducted by systematically evaluating the extent of contrast between the project activities and features (clearing, grading, and fencing the site, and constructing the antenna arrays, groundscreens, powerlines, access roads, and equipment buildings) with the existing dominant features in the landscape. The assessment process segregated the landscape into its primary features (land, water, vegetation, and human modification) and each feature into its basic elements (form, line, color, and texture). Visual impacts are defined as the extent of contrast with the existing landscape features; strong contrasts are defined as significant visual impacts requiring mitigation measures. The extent of visual contrast falls under one of the following categories:

- Weak contrast—landscape change can be seen but does not attract attention from dominant landscape features
- Moderate contrast—landscape change attracts attention and begins to dominate the landscape scene

- Strong contrast (significant impact)—landscape change demands attention and does not go unnoticed by the average observer.

Weak and moderate contrasts are insignificant impacts. A strong contrast is a significant impact which could require mitigation.

Construction impacts from clearing, leveling, and fencing land and constructing antennas, groundscreens, access roads, and other support facilities will result in noticeable modifications to landscape color, texture, and line for most sites. The antennas would introduce a dominant vertical element in landscapes. Bird collision mitigation measures (orange or yellow marker balls or strobe lights) could attract attention to the antenna. Otherwise, at a distance of 3 mi or more, the average observer will have difficulty distinguishing the antenna support towers and backscreen.

Visual impacts related to views from historic properties and historic trails are identified when landscape changes would be visible from the property or trail and would affect its setting and potential eligibility for the NRHP (also see Section 4.13 of this report). Potentially significant impacts could result from construction of CRS antennas within three miles of eligible properties if their eligibility is based upon the property's setting.

4.8.2 Transmit Site

Visual contrasts for both the northern and southern transmit alternative sites would be similar due to the similarity of landscape features and viewer sensitivity. Visual contrasts would be weak to moderate – that is, directly related to the distance from public roads or private residences. Viewer sensitivity would be higher for the few private residences within 0.5 mi of Tx-S where the antenna and support buildings would attract greater attention.

CRS facilities at Tx-N would be 1 mi away and within view of the Columbia Stage Trail and the "half-way house" that are identified historic properties east of the transmit site. Similarly, two

historic properties, the Johnson and Swenson homesteads would be about 3 mi away and within sight distance of Tx-S. CRS construction could degrade the visual setting of those properties (see also Section 4.13).

4.8.3 Receive Site

Visual contrasts for the receive sectors would be similar for both Rx-E and Rx-W. The lower height of the receive antennas (65 ft compared with the 135-ft-high transmit antenna) would result in less contrast at close viewing points than the transmit antennas would cause. Contrasts would range from weak to moderate, depending on distance from the site. Views from less than 0.25 mi would have higher visual contrasts and would attract attention from other dominant features in the landscape, but would not change the overall character of the rural landscape.

Rx-E may be within view of the Woods/Pembina Historic Trail, the first house in Pennington County, and the Lanstad Church historic properties (see Section 4.13). The Pembina Trail would be 0.25 mi from the preliminary site layout, and the house and church would be more than 5 mi away. At a distance of 5 mi, the CRS antennas would be extremely difficult to distinguish, and visual impacts on the first house and Lanstad Church would be unlikely.

4.8.4 Power Supply

4.8.4.1 Transmit Site

Construction of an electric power substation at the transmit facilities and about 60 mi of a 115-kV transmission line from the Groton substation to the south and the Forman substation to the north would result in visual contrasts along the selected powerline routes. Visual sensitivity would be moderate to high from viewing points along most of the transmission corridor because of proximity to rural roads. Landscapes along the alternative routes are common to the geographic region.

Visual compatibility would be moderate along portions of Links 7, 8, and 9 where transmission lines would cross scenic wetland areas, the Wild Rice River, and areas of topographic relief (Link 7) in North Dakota. Viewer sensitivity along these corridors is moderate to high. Although this is a Class B landscape with some scenic features, the transmission line would not significantly detract from the overall scenic quality. The linear element of the transmission line would be compatible with the existing linear elements of roadways and existing powerlines. At other links, visual compatibility would be moderate to high along most of the ROW following existing roads and other transmission lines. The transmission line would not cross any recreational areas, wilderness study areas, or recreational trails. Therefore, visual impacts would not be significant for any of the powerline corridor links for the transmit site.

4.8.4.2 Receive Site

For both Rx-E and Rx-W, the powerlines would be similar to existing distribution powerlines in the area. The planned transmission line would be supported on woodpole towers along existing roads. Visual contrasts would be low to moderate, with the majority of the corridor in a moderate- to high-compatibility landscape. Visual impacts would not be significant for aerial lines within the Rx-W corridor or at any of the three alternative corridors for Rx-E. Powerlines will be placed underground within 0.5 mile of the receive site and may be undergrounded throughout their length. No visual impacts would result from underground lines.

4.8.5 Mitigation Measures

This section lists measures that would mitigate the visual effects of the CRS.

4.8.5.1 General Measures

M4.8.1 - To reduce the extent of visual contrast produced by the CRS support facilities, use neutral exterior colors (e.g., gray-blue, tan, or gray-green).

M4.8.2 - To buffer open views of the sites from rural roads and houses, plant clusters of trees and shrubs at critical locations on the site perimeter.

M5.8.3 - To minimize visual effects of site preparation and earth movement, restore disturbed areas to natural contours and revegetate them.

4.8.5.2 Applicable to Powerlines

M.4.8.4 - To minimize visual effects if Link 7 is chosen for the transmit power line, locate the powerline to prevent skylining along ridges.

4.9 LAND USE

4.9.1 Transmit Site

Construction at Tx-N would result in the transfer of 1,500 acres from pasture to public use (national defense). At Tx-N, approximately 0.2% of the farmland in Brown County and 0.6% of the farmland in Marshall County would be affected. At Tx-S, CRS would require approximately 1,600 acres of agricultural land; all but approximately 100 acres are cropland used for wheat in most years. Those 1,600 acres would represent 0.8% of the farmland in Marshall County. The agricultural land that would be removed from production is a small fraction of the 2 million acres of farmland in the three-county area.

At Tx-N, no Conservation Reserve Program (CRP) lands in or near the preliminary site layout would be affected. At Tx-S, approximately 300 acres of CRP lands could be affected. The CRP contracts would presumably be canceled if the Air Force purchased the land. CRS construction could require removal of protective vegetation on CRP lands.

At Tx-N, no residences lie within the area of the preliminary transmit site layout or buffer zone, and even allowing for shifting the layout within the buffer zone, no residences would be affected. At Tx-S, between six and ten farm houses could be eliminated, depending upon the final

antenna layout. The loss of even ten houses would have a minimal impact on housing inventories in Marshall County, where more than 2,200 residential units have an estimated 450 vacancies.

CRS operation would require restricting the construction of large structures where they would interfere with the CRS beam, defined as the volume above a 1° elevation angle measured from the base of each transmit antenna. This restriction would limit structures to a height of 70 ft at the exclusion fence and to 175 ft at a distance of 10,000 ft in front of each transmit sector. The restriction is not likely affect future construction in the vicinity of the transmit site alternatives because agricultural buildings that tall are uncommon. CRS construction will also require closure of local gravel and dirt roads at either alternative transmit site. No paved roads would be closed (see Section 4.12.2).

4.9.2 Receive Site

At Rx-E, up to 500 acres of cropland and 500 acres of grazing lands, or less than 0.4% of the farmland in Pennington County, would be removed from production. At Rx-W, up to 850 acres of cropland and 150 acres of grazing lands would be lost from production, which represents 0.2% of the farmland in Polk County.

At Rx-E, approximately 1,400 acres of CRP lands would be in or near the preliminary site layout. Depending on the final site configuration, 800-900 acres of CRP land in Pennington County could be affected. At Rx-W, between 120 and 160 acres of CRP land in Polk County could be affected.

Construction at Rx-E would require demolition of two farm houses and one grouping of farm buildings. At Rx-W, three farm houses and associated outbuildings would be affected; in addition, two additional groupings of farm buildings would be affected by the preliminary site layout. Selection of either receive site alternative would have a minimal impact on housing inventories in Pennington and Polk counties. Pennington County is estimated to have more than 700 vacant units, and Polk County has more than 1,900 vacant units.

4.9.3 Power Supply

Power supply for the transmit antenna will require expansion of the substations at Forman, North Dakota and Groton, South Dakota and construction of transmission lines from each substation to the selected antenna site. Substation expansion will require up to 0.25 acre at each substation. The power lines will require the acquisition of an estimated 70 mi of easements with a land area of about 1,273 acres (see Section 2.2.1.4).

The transmission structures will have a minimal effect on land use because farming operations could continue in the ROW. Sensitive resource lands will be avoided to the maximum extent possible during route selection for the line.

4.9.4 Mitigation Measures

Measures that would be applied to alleviate the effect of construction of the CRS on land use are:

M4.9.1 - Allow aerial application of agricultural chemicals in the vicinity of the CRS antennas, although operators of low-flying aircraft will be required to notify the Air Force before they begin their operations.

M4.9.2 - Allow use of arc welders on adjacent properties provided that advance notification of welding is given to the Air Force.

M4.9.3 - Select powerline routes to minimize disruption of resource areas as well as agricultural activities.

M4.9.4 - Uneconomic remnant parcels acquired for CRS but not used for facilities should be made available for leasing for agricultural use.

4.10 RECREATION

4.10.1 Transmit Site

Construction and operation of the CRS transmit facilities will not affect the most popular recreational activities in the CSAs. Most of those activities require a specialized environment, such as a playing course, court, field, or lake, none of which is found at Tx-N or Tx-S.

Recreational activities that could be affected by CRS are hunting, snowmobiling, horseback riding, cross-country skiing, and hiking. These activities require open space and relatively free land access, which would not be available after Air Force acquisition of the CRS site. Because the transmit site will be located on existing private land, however, the only effect will be to prevent continued access by the current landowners and their guests. The general public will not be affected. Thus, the effect of CRS on the recreational habits of the local community and the public at large will not be significant.

4.10.2 Receive Site

Construction and operation of the CRS receive facilities are not likely to affect the most popular recreational activities in northeastern Minnesota, most of which require a specialized environment, such as a playing course, court, field, or lake. None of those is found at either Rx-E or Rx-W.

Recreational activities most likely to be affected by CRS include hiking, hunting, snowmobiling, horseback riding, cross-country skiing, and 4-wheel driving. Those activities require open space and relatively free land access. Land acquisition by the Air Force for the receive facilities will prevent access and impede such activities. Because the receive sectors will be located on existing private land, however, future access limitations will affect only the current landowners and their guests. Thus, the recreational habits of the local community will not be affected.

Hunting, a popular sport in Minnesota, could be affected by the CRS construction and operation. Although hunting ranks tenth as the most frequent recreational activity, the average duration is relatively long - 8 hr per occasion. Unlike South Dakota, the State of Minnesota does not have a formal game protection program that encourages hunting on private property. Because the CRS receiver facilities will be located on existing private farmland, no significant impacts on public hunting activities of the general public in the vicinity of either receive site will result.

4.10.3 Power Supply

The alternative corridors for powerlines to supply electricity to the CRS transmit and receive facilities do not cross public parks, recreation areas, or wildlife refuges. The powerlines will be located for the most part on private agricultural land and will probably parallel existing roads. In general, the presence of power lines will not hinder the pursuit of recreational activities. Activities such as walking, hiking, biking, jogging, and field events occur along roads, trails, and in fields where power lines could be located, but the powerlines would not limit those activities. Although the existing landowner will retain ownership of the ROW, hunting in the vicinity of power lines could be hazardous to the hunter, and hunting within the power line ROW would be discouraged. Because the ROW will be located predominantly on private land, the limitations on hunting due to the presence of the powerlines will affect only the landowners and their guests. That will be insignificant.

Swimming, softball, golf, boating, tennis, and net sports require a specialized court or a sizable natural or man-made body of water. The powerlines will not be built across playgrounds, developed recreational fields, or large water bodies. Those activities, therefore, will not be affected.

4.10.4 Mitigation Measures

Recreational areas or recreational opportunities available to residents of the study areas would not be significantly affected. Therefore, no mitigation is required or recommended.

4.11 SOCIOECONOMIC EFFECTS

4.11.1 Transmit Site

This subsection analyzes possible effects from construction and operation of CRS on overall employment and personal income, housing demand, and property tax revenues available to counties and school districts.

4.11.1.1 Job and Income Changes

Construction of the initial two transmit sectors will begin in 1991. If all four sectors are built, construction activities could last until 1997. Benefits to the local economy will be generated by spending for supplies and services by the construction contractor, local hiring of construction workers, and spending by construction workers and the permanent work force. Local spending will be distributed according to the availability of supplies and services, convenience, and predilection of the contractor. Aberdeen is the largest community in the area and will likely capture most local spending.

The prospect for local hiring in Brown, Day, and Marshall counties will be governed by the location of contractors, the hiring practices of the contractors, and the local availability of the required skills. Some contractors bring in a management group and rely heavily on local subcontractors and individual skills; others import nearly all their work force, including laborers.

Throughout the project, some trades will be on site for extended periods and others for only a few weeks. The project will be divided into two phases, each involving the construction of two of the four transmit sectors. During construction, an average of 60 construction workers will be employed at each transmit sector, for a total of 120 workers. Maximum construction employment at the transmit site will be about 220 workers.

Some construction labor will be hired locally, and some will be imported. Consequently, it is anticipated that some workers will reside in the Amherst/Langford/Hecla area near the transmit

construction site, and others will commute daily and weekly from their permanent residences. Aberdeen, located 30 mi southwest of Tx-S is the largest city in the region with a population exceeding 25,000. Much of the construction labor is likely to commute from the Aberdeen area.

Contractors will spend an estimated $2.86 million in wages annually (1994 dollars) for construction labor. This estimate is based on the 1986 average annual construction salary for Brown County (South Dakota) of $16,721 (U.S. Bureau of the Census, 1986), average annual construction employment of 120 workers, and a 4.5% annual inflationary rate. (The WEFA Group, 1989)

Construction of the primary and secondary power transmission lines for the transmit antenna will require 25-30 employees for up to 24 months at an estimated cost of $1.09 million annually (1994 dollars). This estimate is based on the 1986 average annual salary of $25,526 for electric, gas, and sanitary service workers in South Dakota and average wage inflation of 4.5% per year. (U.S. Bureau of the Census, 1986)

Substation construction at both Groton and Forman will require an estimated ten construction workers over approximately 6 months. The CRS transmit site substation will require an estimated 15 construction workers over an approximate 8-month period. Total labor cost for substation construction will be approximately $442,000 annually (1994 dollars). This cost estimate is based on the 1986 average annual salary of $25,526 for electric, gas, and sanitary service workers in South Dakota of (U.S. Census, 1986) and an annual inflationary increase of 4.5%. (The WEFA Group)

The transmit facility will have a permanent staff of about 25 workers. Two or three of this group will be military personnel, the remainder will be civilians. Five or six employees will work at the site during each 8-hr shift. The staff will operate and maintain the system from the equipment buildings at each sector and will conduct security patrols on the perimeter roads. Total labor cost for transmit site operation will be approximately $468,000 annually (1994 dollars), based on a $9 hourly wage.

Construction of the transmit antennas will remove some agricultural land from production, resulting in a loss of jobs and regional income. Land at Tx-N is pasture land which would support a cow-calf operation at about one cow per 5 acres. (Mills, 1990) Up to about 2,000 acres of land could be acquired for CRS transmit construction; this land would carry about 400 cow-calf pairs. Assuming that the gross value of production is $352 dollars per cow (USDA, Economic Research Service, 1989), potential revenue from Tx-N is approximately $141,000 dollars annually. Using earning and job multipliers for South Dakota (U. S. Department of Commerce, 1986), this amount translates into a loss of approximately $75,000 in personal income and seven jobs for the region, including both direct effects in the agricultural sector and indirect effects in supply sectors.

Land acquisition at Tx-S would remove up to 2,000 acres of cropland from production. For wheat growers in the area, the annual value of production has ranged between $53 and $121 per acre over the period from 1980 to 1988. (South Dakota Agricultural Statistics Service, 1989) Based on an assumed gross revenue of $100 per acre, total revenue lost would be approximately $200,000. Using earning and job multipliers for South Dakota (U. S. Department of Commerce, Bureau of Economic Analysis, 1986), that would result in a loss of approximately $110,000 in personal income and ten jobs for the region.

The economic benefit from construction and operation of the CRS transmit sectors will be greater than the total direct and indirect effects of the decrease in agricultural production. In comparison to an estimated loss from displacement of agricultural uses of up to $110,000 in personal income and less than ten jobs, CRS will generate, for 4 to 7 years, in excess of $3 million in wages and 120 construction jobs. During operation, the direct gains will be approximately $500,000 in income and 25 jobs. Thus, the net direct gain will be about $2.9 million and 110 jobs during construction and $390,000 and 15 jobs during operation.

Indirect economic benefits will also result. The construction employment multiplier is estimated at 2.33 and the operations multiplier at 2.07. (U.S.Department of Commerce, Bureau of

Economic Analysis, 1986) Because may construction workers will be from outside the local area and because there are few local retail outlets, the indirect local impact will be somewhat less than indicated by the multipliers.

4.11.1.2 Housing Demand and Population Growth

Tx-N is located near the town of Hecla. The area is less populated than the Tx-S area, where there are no farmhouses within the preliminary site layout. Construction of CRS transmit sectors may prompt adjacent residents to relocate

Tx-S is located near the town of Langford. The preliminary site layout would require the demolition of six to ten farmhouses. This could result in the relocation of 17-28 individuals, based on the 1980 average household size for Marshall County. (U.S. Bureau of Census, 1983)

During construction, some of the construction workers will travel from outside of the region, and others will come from local communities. Nonresident workers might seek housing in nearby transient facilities such as motels, recreational vehicle (RV) parks, and state- and county-operated camping facilities. It is not known how many nonresident workers of the peak 220 workers will establish temporary housing. Those individuals will likely first seek accommodations near to the site and then toward the Aberdeen area. Typically, few construction workers are accompanied by their families.

The nearest transient housing, located in Aberdeen, has more than 270 AAA-affiliated rooms (AAA, 1990). The area also has RV parks and camping facilities at state parks and recreation areas. Aberdeen is expected to house most transient workers because it offers many urban services.

In addition to locally available lodging facilities, unoccupied housing units are sufficient to satisfy the demand for housing created by CRS construction and operation. Vacant houses in the tri-county area have increased from 1,708 in 1980 to an estimated 2,052 in 1988. These houses,

combined with the 270 motel/hotel rooms available in Aberdeen, are sufficient to house the up to 220 temporary construction workers during peak employment periods.

About 25 operational staff will be employed at of the CRS transmit site; two or three will be military personnel. This added employment could result in the relocation of 25 individuals and their families to the area. Based on the 1986 average U.S. household size of 2.67, this could increase area population by 67 persons.

4.11.1.3 Fiscal Effects

Construction of the CRS transmit antennas could remove up to 4,000 acres of agricultural land from local tax rolls. This would reduce revenues available to the county governments and school districts.

Tx-N lies in both Brown and Marshall counties. If the Air Force acquired 2,000 acres in Brown County and that land were assessed at the average value for all land in the county, the decrease in the county's assessed value would be approximately $450,000. That amount represents 0.2% of the total assessed value of land in Brown County. Applying the same procedure to 3,000 acres of land in Marshall County would result in a decrease of approximately $535,000 in the county's assessed value, representing less than 0.5% of the total assessed value of land in the county. Tx-N is partly in the Hecla School District and partly in the Britton School District. Land acquisition would reduce the total assessed value of the Hecla District by about 2.0% and the assessed value of the Britton School District by 0.8%.

Land acquisition for Tx-S in Marshall County would reduce the county's assessed value by approximately $712,000, roughly 0.6% of the total assessed value of land in the county. Tx-S is located in the Langford School District, which has a total assessed value of more than $41 million. CRS land acquisition could remove approximately 1.7% of assessed value in the district from the tax rolls.

The impacts on the assessed values estimated above overstate the net fiscal impact because the counties and school districts receive money from sources other than property taxes. Including federal and state revenues, the decrease in total revenues would be 1.1% for the Hecla School District, 0.6% for the Britton School District, and 1.1% for the Langford School District. If a portion of the transmit site were leased instead of purchased by the Air Force, the impact on local government revenues would be reduced.

4.11.2 Receive Site

4.11.2.1 Job and Income Changes

Construction of the initial two CRS receive sectors in Minnesota will occur concurrently with construction of the transmit sectors in South Dakota, beginning in 1991 and continuing until about 1994. Construction of the final two sectors at the receive and transmit sites will probably occur during 1994 through 1997.

Benefits to the local economy will be generated by spending for supplies and services by the construction contractor, local hiring for construction, and spending by construction workers and the permanent work force. Local spending will be distributed according to the availability of supplies and services, convenience, and predilection of the contractor. Thief River Falls Minnesota and Grand Forks, North Dakota are the largest communities in the vicinity and will likely capture most of the local spending.

Local hiring of construction workers will be governed by the location and hiring practices of the contractors and the local availability of required skills. Some contractors bring in a management group and rely heavily on local subcontractors and individual skills; others import nearly all their work force, including laborers.

Throughout the project, the need for trades will vary. Some trades will be on site for the duration of construction; others will be needed for only a few weeks. As at the transmit site, an

average of 60 construction workers will be employed at each receive sector. Two of the four sectors will be simultaneously under construction, employing a average total of 120 workers. Maximum construction employment will be 220. Construction of the powerlines will probably require fewer than 20 workers.

As described above for transmit site construction, some construction labor for the receive site will be hired locally, and some will be imported. Consequently, it is anticipated that some workers will reside near the construction site, and others will commute daily and weekly from their permanent residences. Thief River Falls, population 9,100 and located 8 mi east of Rx-E, and Grand Forks, population 45,800 and located 25 mi southwest of Rx-W, are the largest communities in the region. Much of the construction labor is likely to commute from those areas.

Contractors will spend an estimated $2.95 million annually (1994 dollars) for construction labor at the CRS receive sectors. This estimate is based on the Polk County, Minnesota, 1986 average annual construction salary of $17,279 (U.S. Bureau of the Census, 1986), average annual construction employment of 120 workers, and a 4.5% annual inflation rate. (The WEFA Group, 1989)

Construction of the receive-site powerlines will require as many as 20 additional employees for as long as 1 month at an estimated labor cost of $78,000 (1994 dollars). These calculations are based on the 1986 average annual salary of $32,938 for electric, gas, and sanitary services workers in Minnesota and an annual 4.5% wage increase.

The receive facility will have a permanent staff of about 25 workers; two or three of these workers will be military personnel and the remainder civilians. About five or six employees will work at the site during each 8-hr shift. The staff will work within the equipment buildings at each sector and will conduct security patrols on the perimeter roads. Total labor cost for receive-site operation will be approximately $465,000 annually (1994 dollars), based on a $9 hourly wage.

Construction of the receive antennas will remove up to 1,000 acres of agricultural land from production, resulting in a loss of jobs and regional income. Land at Rx-E is approximately 50% cropland and 50% pasture. For wheat growers in the area, the annual value of production has ranged between $100-$160 per acre over the period from 1980 to 1988. (Minnesota Agricultural Statistics Service, 1989) Assuming that cropland produces wheat worth $150 per acre, output on 500 acres of wheat is about $75,000. Based on the assumptions that the pastureland supports a cow-calf operation at about one cow per 5 acres and that the gross value of production is $352 dollars per cow (USDA, Economic Research Service, 1989), the potential decrease in livestock revenue from Rx-E would be approximately $35,000 annually. Using earning and job multipliers for Minnesota (U.S. Department of Commerce, 1986), the reduction in crop and livestock output of $110,000 would result in a loss of approximately $68,000 in personal income and six jobs for the region (including both direct effects in the agricultural sector and indirect effects in supply sectors).

Land acquisition at Rx-W would remove up to 850 acres of cropland and 150 acres of pastureland from production. Based on an assumed gross revenue of $150 per acre, total crop revenue lost would be approximately $127,500. Potential losses in livestock revenue from Rx-W would be approximately $10,600 annually. Using earning and job multipliers for Minnesota (U.S. Department of Commerce, 1986), the reduction in crop and livestock output due to CRS would be $138,100, and would result in a loss of approximately $84,000 in personal income and eight jobs for the region (including both direct effects in the agricultural sector and indirect effects in supplying sectors).

Construction and operation of the CRS receive antenna will have a net positive impact on the regional economy. The direct effects alone will be greater than the total direct and indirect effects of decreases in agricultural production. In comparison to a maximum estimated loss of $138,100 in personal income and eight jobs, CRS would generate more than $3 million in wages and 120 jobs during construction for a net increase of about $2.9 million in personal income and 112 jobs

during construction. During operation, the net gain will be approximately $370,000 in income and 17 jobs. The indirect impact of that job growth will be greater due to the multiplier effect. The multiplier for construction employment is estimated at 2.29 and for operations at 2.20. Because many construction employees will be from outside the local area and because there are few local retail outlets, the indirect local effects will be less than indicated by the multipliers.

4.11.2.2 Housing Demand and Population Growth

Rx-E is located near the city of Thief River Falls. The proposed site layout would require the demolition of two farmhouses. That would result in the relocation of six individuals, based on the 1980 average household size for Pennington County. (U.S. Bureau of the Census, 1980) CRS construction could also prompt adjacent residents to relocate out of the area.

Rx-W is located near the town of Warren, Minnesota. The proposed site layout would require the demolition of three farmhouses and two farm structures. That would result in the relocation of nine individuals, based on the 1980 average household size for Polk County. (U.S. Bureau of the Census, 1980)

During construction, nonresident workers might seek housing in nearby transient facilities such as motels and RV parks. A reliable estimate how many nonresident workers workforce will establish a local residence cannot be made. Those individuals will likely first seek accommodations near the site, then toward the cities of Thief River Falls and Crookston, Minnesota, and Grand Forks, North Dakota. Typically, few construction workers are accompanied by their families.

The nearest transient housing facilities are located in Thief River Falls, which has a total of 112 rooms in AAA-affiliated motels (AAA, 1990). The next largest community is the Grand Forks, North Dakota area with a total of 850 rooms in AAA-affiliated motels. (AAA, 1990) The area also has RV parks and camping facilities at state parks and local recreation areas. Thief River Falls and Grand Forks are expected to house most transient workers because of their array of urban services.

In addition to locally availability lodging facilities, unoccupied housing units are sufficient to satisfy the demand for housing created by CRS construction and operation. Vacant houses in the four-county area have increased from a total of 2,852 in 1980 to an estimated 3,880 in 1988. This housing, combined with the 962 motel/hotel rooms available in a 35-mi radius from the receive site are sufficient to house the up to 220 temporary construction workers during peak employment periods.

Similar to the transmit facility staffing, the operational staffing of the CRS receiver facilities will be about 25 employees, with two to three being military personnel. This added employment could result in the relocation of 25 individuals and their families to the area. Based on the 1986 average U.S. household size of 2.67 (U.S. Bureau of the Census, 1987), this could increase area population by 67 persons.

4.11.2.3 Fiscal Effects

Construction of the CRS receive antennas could remove up to 2,000 acres of agricultural land from local tax rolls. This could reduce tax revenues available to the county governments and school districts.

Rx-E lies in Pennington County. Assuming that 2,000 acres of land were acquired by the Air Force and that the land were assessed at the average value for all land in the county, the decrease in the county's assessed value would be approximately $500,000, or 0.7% of the total assessed value of land in Pennington County. Rx-E is in the Thief River Falls School District, which has a total assessed value of nearly $51 million. Land acquisition could remove up to 1.0% of assessed value from the tax rolls in the district.

Applying the same procedure to 2,000 acres of land at Rx-W in Polk County would result in a decrease of approximately $360,000 in the county's assessed value. This represents less than 0.2% of the total assessed value of land in Polk County. Rx-W is in the Warren School District,

which has a total assessed value of nearly $103 million. Air Force acquisition of 2,000 acres for CRS facilities would remove up to 0.4% of assessed value from the tax rolls in the district.

The above analysis of impacts on assessed valuation overstates the fiscal impact because counties and school districts affected receive money from sources other than property taxes. Including federal and state funding, the decrease in total revenues due to the CRS would be 0.3% for the Thief River Falls School District and 0.1% for the Warren School District. If a portion of the CRS site were leased rather than purchased, the impact on local government revenue would be reduced.

4.11.3 Power Supply

Powerline construction will result in a temporary increase in employment. Maintenance and operation of the powerlines will be performed by existing maintenance personnel for the Western Area Power Administration (WAPA) and the applicable electric cooperative in Minnesota; little, if any, permanent new hiring will occur.

For construction of the CRS transmit-site powerlines, on-site substation, and substation expansions, maximum construction employment will be 60-65, and average employment over the 2-yr period will be about 25. Many of those employees will be local residents, and some could be drawn from out of the area. The housing supply in southeastern North Dakota and northeastern South Dakota is able to accommodate the expected influx of temporary residents during construction.

Construction of the powerline for the CRS receive facilities will employ up to 20 workers, for about one month. Only a small portion of the work force is expected to be from outside the area. The available housing supply can accommodate any influx of employees.

The ROWs for the CRS powerlines will be easements acquired from landowners who would continue to pay property taxes on that land. No land would be acquired for expansion of the

Forman and Groton substation because the existing WAPA land is adequate for that expansion. Fiscal impacts on local governmental agencies will be insignificant.

Agricultural uses of land within the powerline ROWs can continue after construction of the lines. Only the small area surrounding each structure, which will be less than 300 ft^2, will be unusable. The total amount of land removed from production will be less than 5 acres for the transmit-site powerlines and less than 2 acres for the receive-site powerlines. The resulting loss in agricultural revenue will be negligible and will be offset by payments from the power companies for ROW use.

4.11.4 Mitigation Measures

No significant impacts on population, housing, employment, and income will result from construction and operation of CRS. In fact, project effects on employment and income will be beneficial to the communities, and no mitigation will be required. The following measure would mitigate fiscal impacts on local governments agencies:

M4.11.1—To offset adverse impacts on local property tax revenues, lease rather than purchase land.

4.12 TRANSPORTATION

4.12.1 Methodology

This section of the EIS, except for Section 4.12.4 on power-supply transportation effects, summarizes information from Technical Study 3, Central Radar System Over-the-Horizon Backscatter Radar Program, Transportation, prepared by Metcalf & Eddy/Holmes & Narver (1990C), the facility integration associates for the project. That technical report analyzed traffic generation, roadway closures and realignments, and measures that could reduce possible project impacts.

To analyze project effects on traffic flow, Level of Service (LOS) analyses were performed for sections of major paved roads that would receive heavy use by construction vehicles. Level of Service is described by the categories A through F. Levels A, B, and C describe stable flow, LOS D describes nearly unstable flow with some delays for motorists, and LOS E and F describe unstable flow with moderate to severe delays for motorists. Table 4.12.1 describes LOS ratings in more detail. In general, LOS C or better is considered acceptable for rural areas. Consequently traffic generation that would reduce LOS to D or lower would be a significant impact.

Traffic volumes for roads at the CRS study areas are available only as average daily traffic volumes (ADT), while LOS analysis is based on peak hour volumes. Therefore, it was assumed that 10% of the existing ADT occurs in the peak hour and that all commute trips by construction workers also occur in the peak hour. CRS truck traffic will be relatively evenly spaced throughout the day; about 10% were assumed to occur during the peak hour.

4.12.2 Transmit Site

4.12.2.1 Tx-N

The proposed site layout will result in closure of the end portions of existing dirt roads accessing the site from the north, east, and west. None of those roads are through-roads, and

Table 4.12.1
LOS DESCRIPTIONS
FOR TWO-LANE HIGHWAYS

LOS	Description
A	Free flow with low traffic volumes and relatively high speeds; little or no reduction in maneuverability due to other vehicles.
B	Stable flow with operating speeds relatively unaffected; slight deterioration of movement within the main traffic stream.
C	Stable flow but speeds and maneuverability begin to be restricted; motorists entering from side streets experience average delays.
D	High density traffic approaching unstable flow; speeds and maneuverability become more significantly restricted.
E	Traffic volume at or near road capacity; maneuvering within the traffic stream is extremely difficult.
F	Forced flow with queuing of vehicles; breakdown of flow and erratic vehicle movements.

Source: Metcalf & Eddy/Holmes & Narver, 1990C; SRI International

closure will only affect access to the site itself. Because the site will be a secured area after construction, public access will not be desirable or allowed, and the lack of access would not inconvenience the public. Brown County Route 5 and Marshall County Route 4 would not be physically affected by CRS construction.

Britton, roughly 17 mi southeast of the site, is the most likely place for construction workers to live. They would commute to the site via either Marshall County Route 4 or Route 10. Construction-related traffic would probably access the site via either U.S. 28 to the west or Interstate 29 to the east and Route 10, with some trucks using Brown County Route 5/Marshall

County Route 4. The peak period for construction traffic generation will occur during site preparation. Up to 340 trips during the peak hour will result from construction activities. At Brown County Route 5/Marshall County Route 4, the peak hour traffic volume could increase from 6 to 346, reducing LOS from its existing A to C. At Route 10, the peak-hour traffic volume could increase from 74 to 414, and LOS would drop from A to C. Those would be insignificant impacts.

4.12.2.2 Tx-S

The proposed site layout would not affect Marshall County Route 16, which is a paved road. Marshall County Route 11 would be located between the east and west sectors and between the southeast and southwest sectors. During construction and operation, it could be necessary to close the section of that road within 2.5 mi of Route 16 for operational, safety, or security reasons; this would force motorists to use alternate gravel-surfaced routes to the east or west. The creation of a gap in the CRS road grid could somewhat increase the length of trips by local motorists. The temporary closure of Route 11 during construction would force motorists to travel for several miles on dirt and gravel roads.

Additionally, about 5 mi of north–south dirt and gravel roads 1 mi east and west of Route 11 would be closed. Also, about 5 miles of east–west dirt and gravel roads that are parallel to and 1 to 2 mi north of Route 16 would be closed. That would create a 2.5 mi by 2.5 mi gap in the existing road grid of the CSA. Other existing roads and the CRS perimeter roads would facilitate travel around the site.

Peak-hour trip generation would be about the same as described above for Tx-N. It is expected that construction workers would primarily commute from Aberdeen, which is approximately 35 mi from this site, or Britton, which is 10 mi from the site. The largest impacts from construction traffic would occur on Routes 11 and 16. During site preparation, when construction-related traffic would be highest, peak-hour traffic volume on Route 16 would increase

from 24 to 364, reducing LOS from its existing A to C. On Route 11, peak-hour traffic volume would increase from 10 to 350, and LOS would decrease from A to C. Those changes would be minor impacts.

4.12.3 Receive Site

4.12.3.1 Rx-E

The proposed layout at this site could affect Route 64. Up to 2 mi of Route 64, a gravel and dirt east–west road, would be closed. That route has an ADT of 70 east of the site, and probably a lower ADT at the site because the road changes on the site from a compacted gravel surface to a dirt surface. Motorists could use either the dirt perimeter road or Route 65, which parallels Route 64 one mi to the north, as an alternative. Given the low usage of Route 64 and the availability of alternatives, closure of that road would be a minor impact.

The buffer zone for the southwest sector crosses about one-eighth mi of Route 8. That short stretch of roadway would not be physically affected.

Traffic generation will be about the same for the receive site as described above for the transmit site. It is likely that construction workers and trucks would travel to the site from Thief River Falls and other towns in the area such as Crookston and, Warren, Minnesota, and Grand Forks, North Dakota. Construction traffic accessing the site would probably use either Routes 1 or 8 and Route 10. During the period of highest construction activity, peak-hour traffic volumes on Route 8 could increase from 63 to 403. Peak-hour traffic volumes on Routes 1 could increase from 100 to 440. For both those roads, LOS would decrease from A to C, changes which would be minor impacts.

4.12.3.2 RX-W

The proposed layout for this site would affect about 1.4 mi of compacted gravel road and about 1.6 mi of dirt road. A 0.4-mi stretch of Route 68, a compacted gravel road, would be closed and replaced by a section of CRS perimeter road, increasing travel distance by about 0.2 mi. The existing dirt road on the section lines between Sections 16–17 and 20–21 would be cut for about 1 mi of its length. The shortest detour would require traveling on the existing gravel road 1 mi to the south, an additional distance of about 2.5 mi.

Also, the existing east–west gravel road between Sections 20–21 and 28–29 would be cut for 1 mi of its length. As an alternate route, the CRS perimeter road would be about 0.25 mi longer and have a lower quality dirt surface.

Finally, the north–south dirt road on the section line between Sections 15 and 16 would be cut for 0.6 mi of its length. The CRS perimeter road alternative would be 0.7 mi longer than the existing road. The existing gravel road 1 mi to the east would also be an alternate route.

Other than the closure of the east–west dirt road across the center of the site, all of the road closures would result in negligible effects. Closure of the dirt road at the center of the site would force motorists to travel about 2.5 mi farther than at present, which would moderately inconvenience a small number of motorists.

Traffic generation and travel routes would be the same as described above for Rx-E. The primary access routes to this site would be Route 1 to Route 68 or Routes 8, 23, and 69. During the most active construction period, peak-hour traffic volumes on Routes 1 and 8 could increase as described above for Rx-E. LOS would decrease from A to C. On Routes 23, 68 and 69, peak-hour traffic volumes could increase from 75-105 to 415-445. LOS analysis does not apply to those roads because they are unpaved.

4.12.4 Power Supply

Construction of the powerlines, and expansion of the substations will generate traffic from commuting workers and delivery of supplies and equipment by trucks. About 15 employees will work on the on-site substation, generating up to 30 one-way trips per day. An additional 100-150 truck trips will occur over the 8-month construction period for the on-site substation. Those trips will be insignificant compared to the traffic generated by construction of the other CRS receive facilities and will occur after the peak traffic generation due to site preparation. No change in the LOS calculated above will result.

At both the Forman and Groton substations, work on the substation expansions will occur over about 6 months. About 10 workers will be employed, and a total of 50-100 truck deliveries will be made. The amount of traffic generated will be insufficient to affect the LOS of local roads. Those substations are distant enough from the CRS sites that traffic will use different roads than those used by the site construction workers and trucks.

Construction of powerlines for the CRS transmit site will require 25-30 workers and several truck trips at each structure location. As work on the powerlines progresses, the area affected by that traffic will move. The number of trips generated will not be large enough to affect LOS of local roads.

Construction of the on-site substation at the CRS receive site will require 15 workers and up to 100 truck deliveries, distributed over a period of several months. Traffic generation will be negligible compared to the traffic generated by construction of the other CRS receive facilities. Installation of the powerlines will employ up to 20 workers for several months. Additionally, several trucks will travel to each powerline structure location. Traffic associated with powerline construction will be distributed over the length of the line. No changes in LOS of local roads will result.

During CRS operation, WAPA will periodically inspect powerlines serving the CRS transmit site, and the selected electric cooperative will inspect the receive-site powerline. Those inspections will be done from aircraft or ground vehicles. The amount of traffic generated will be insignificant.

4.12.5 Mitigation Measures

The most significant transportation impact of CRS would be road closures. Measures M4.12.1 and M4.12.2 are required to mitigate that impact to insignificant levels.

4.12.5.1 General Measure

M 4.12.1—To minimize disruption of established transportation patterns, the Air Force will use existing roads as feasible and will allow public use of the CRS perimeter roads, which will be of equal or better quality than closed roads.

M4.12.2—To compensate for road deterioration due to construction vehicle travel, repair any roads damaged by construction traffic.

4.12.5.2 Applicable to Tx-S

M 4.12.2—To minimize inconvenience to motorists, keep Route 11 open for public use.

4.12.5.3 Applicable to Rx-W

M 4.12.3—To minimize public inconvenience, construct the section of CRS perimeter road replacing the closed portion of Route 68 with the same surface type and road width as the existing Route 68.

4.13 CULTURAL RESOURCES

4.13.1 Overview

In conjunction with the guidelines implementing NEPA, Section 106 of the National Historic Preservation Act (NHPA) of 1966 (as amended) and the American Indian Religious Freedom Act (AIRFA) of 1978 form the primary basis for assessing the effects of project actions on significant cultural resources. Under NHPA, significant cultural resources are those resources that are listed or eligible for listing on the National Register of Historic Places (NRHP). Under AIRFA, federal agencies, in consultation with appropriate Native American groups, are required to evaluate project actions with the aim of protecting and preserving Native American religious freedom and practices. Significant impacts on cultural resources are those that affect the eligibility of a significant cultural resource for inclusion on the NRHP or adversely affect a Native American traditional, religious, or sacred site. Impacts could consist of physical damage to properties or of visual effects on their settings.

Air Force policy on historic preservation is set forth in AF Regulation 126-7, and commits the Air Force to:

- Inventory, evaluate, and protect historic resources located on lands controlled by the Air Force
- Identify and nominate to the National Register all eligible historic resources on Air Force lands
- Cooperate with federal, state, and local agencies, Native American tribes, and the public in managing historic resources
- Integrate historic preservation requirements with planning and management of other activities, and consider historic resources during the earliest stages of project planning to reduce conflicts with the military mission and other management objectives

- Maintain historic resources and promote their rehabilitation and adaptive reuse when feasible
- Recognize the rights of Native Americans to have access to certain religious sites and objects on lands under Air Force control within the limitations of the military mission.

Following this policy, and to comply with NHPA and AIRFA, the Air Force has developed, in consultation with the Advisory Council on Historic Preservation (ACHP) and the Minnesota, South Dakota, and North Dakota State Historic Preservation Offices (SHPOs), a Draft Programmatic Agreement (PA) addressing the management of historic properties affected by CRS construction. The PA will incorporate the Cultural Resources Management Plan (CRMP) prepared for CRS, which specifies procedures for the identification, evaluation, and treatment of cultural resources and cultural resource sites throughout the EIAP and beyond.

4.13.2 Transmit Site

Based on background research and sample survey work conducted for the transmit study area, resource density is projected to be low at both the northern and southern CSAs. Background research identified two historic archeological sites in the northern CSA and two historic architectural/agricultural sites in the southern CSA that could be affected by construction of the transmit antenna. The sample survey did not identify any cultural resources that were initially evaluated as significant and therefore eligible for listing on the NRHP. There are no known Native American traditional, religious, or sacred sites which would be affected by the CRS.

Construction activities at the transmit site would disturb about 511 acres at Tx-N and about 504 acres at Tx-S. Significant archeological resources present within the areas of ground disturbance could be harmed by construction activities. Possible effects include physical destruction by heavy equipment used in soil grading and construction, deep burial under earth fill, or covering by structures. If borrow areas are developed on site, gravel extraction would cause

major alterations on the ground surface, and any significant cultural resources present could be affected.

Significant historic structures identified within the area of project effect could be damaged and those located near the site could be visually affected. Native American traditional, religious, or sacred sites identified in or near the sites could be visually affected. Human burial sites within the area of ground disturbance could be destroyed. Construction of approximately 2 mi of access roads at the northern CSA and 1 mi the southern CSA would increase access to small areas formerly not accessible to the public. Impacts could result from uncontrolled collection of cultural artifacts or vandalism to an archeological or architectural site located on property outside the secure exclusion zone.

The presence of construction and operations staff unfamiliar with regulations governing cultural resources on federal property could result in uncontrolled collection of cultural artifacts or damage to an archeological or architectural site.

4.13.2.1 Tx-N

Based on the discovery of the three historic architectural sites during the sample survey, an estimated total of 23 sites of that type could occur in of the northern CSA. None of the sites is expected to be a significant property.

The transmit antennas would be visible from the half-way house stage stop and wagon ruts associated with the old Columbia Stage Trail located slightly more than 1 mi from the eastern boundary of the transmit site. The presence of the antennas would change the landscape setting of those sites and result in visual impacts, an important result if the properties are determined eligible for inclusion on the NRHP.

4.13.2.2 Tx-S

Based on the findings of the sample survey, an estimated 50 sites could occur in the southern CSA, including 33 prehistoric fieldcamps and 17 historic dumps/homesteads. Although such sites could occur in any part of the southern CSA, prehistoric fieldcamp sites would probably be located near ephemeral streams.

Two prehistoric field camps were discovered by sample surveys conducted at Tx-S. Although the sites are probably not significant, they should be tested and evaluated for NRHP eligibility if Tx-S is selected for the transmit site. If found to be NRHP-eligible, significant impacts would result from CRS construction.

Construction of CRS facilities at the Tx-S could affect the visual settings of the Johnson and Swenson homesteads located 2.0 and 3.5 mi, respectively, southwest of the preliminary site layout. Although the CRS facilities would be on the distant horizon as viewed from those homesteads, views of the transmit antennas could change the landscape setting and result in visual impacts, particularly on the Johnson homestead. The Swenson homestead is distant enough that visual impacts from CRS would be insignificant. The homesteads are currently listed as potentially eligible for inclusion on the NRHP. Further evaluation is required to fully determine their eligibility status. Because the NRHP eligibility of the Augustana Lutheran Church is not related to its setting, visual impacts on that historic property would be insignificant.

4.13.3 Receive Site

Based on background research and physiographic features of the receive study area, resource density is projected to be high for the eastern CSA and lower for the western CSA. Impacts are anticipated for the eastern CSA. To date, no Native American traditional, religious, or sacred sites have been identified, although according to a Devils Lake Sioux tribal member, a traditional site may be located between Thief River Falls and Crookston. Areas of high resource potential are

located along the beach ridges of glacial Lake Agassiz (See Figure 4.13.1) and along ephemeral streams and marshy areas.

Construction activities would disturb about 527 acres at Rx-E or Rx-W. Significant archeological resources present within the area of ground disturbance could be destroyed by site preparation and construction activities. Possible effects include physical destruction by heavy equipment used in soil grading and construction, deep burial under earth fill, or covering by structures. If borrow areas are developed on site, gravel extraction would cause major alterations on the ground surface, and any significant cultural resources present would be affected. Significant historic structures identified within the area of project effect could be damaged. Those located in the proximity of the site could be visually affected. Construction of approximately 1 mi of access roads at the eastern or western CSA would increase access to small areas formerly not accessible to the public and outside the secure exclusion area. Impacts could result from uncontrolled collection of cultural artifacts or vandalism to an archeological or architectural site. The presence of construction and operations staff unfamiliar with regulations governing cultural resources on federal property could result in impacts caused from uncontrolled collection of cultural artifacts or damage to an archeological or architectural site.

4.13.3.1 Rx-E

At the eastern CSA, both the recorded and unrecorded portions of the Woods/Pembina Historic Trail are located within one-quarter mile of the proposed receive site. The CRS receive facilities would be visible and would change the landscape setting, resulting in visual impacts to the recorded segment of that trail. potential visual impacts would also occur to the unrecorded portion of the trail if it is evaluated as eligible for the NRHP or recommended for preservation.

Archeological sites are expected to occur along the beach ridge areas located within one-quarter mile of Rx-E. The potential for significant Paleo-Indian occupation sites and Woodland burial mound sites to exist is high and, if within the area of construction disturbance, significant impacts could result.

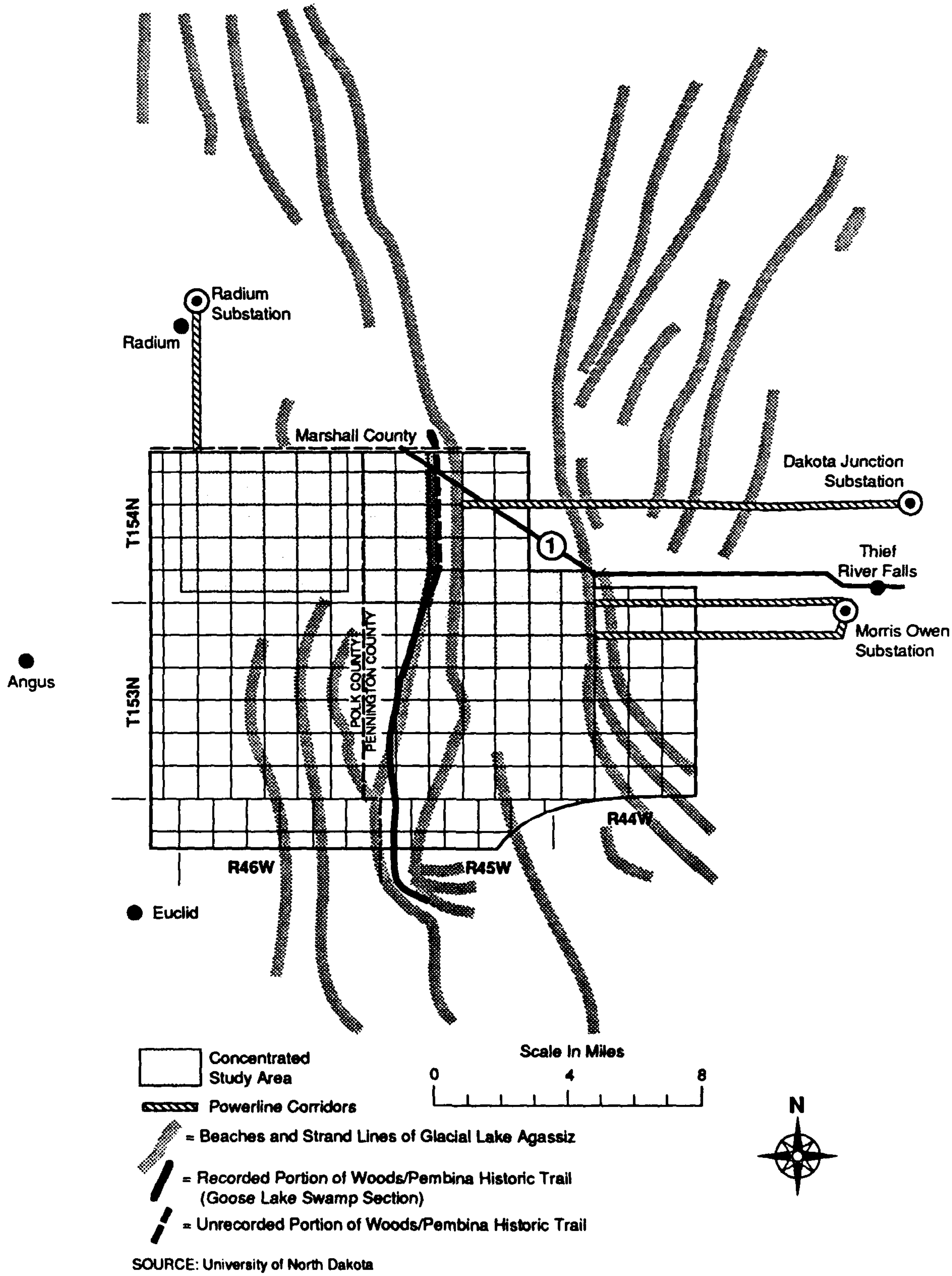


FIGURE 4.13.1 BEACH RIDGE AREAS OF GLACIAL LAKE AGASSIZ, CRS RECEIVE STUDY AREA, MINNESOTA

4.13.3.2 Rx-W

The western CSA contains no recorded historic properties, and no impacts are anticipated.

4.13.4 Power Supply

4.13.4.1 Transmit Site

Based on the results of background research and consideration of physiographic features, prehistoric archeological resource potential for the proposed transmit powerline corridors is low. Resource density is expected to be generally higher for links located in the till plain physiographic region (Links 7-10) with an estimated 1.2 to 1.5 sites per 1,000 acres. A lower site density is generally anticipated at Links 1-6. Areas of higher resource potential are located near water bodies and marshlands. Historic architectural resource potential is expected to be moderate overall, with an average of two rural sites per mile, and additional urban sites.

For historic architectural sites identified through the literature and records search which are not currently listed on the NRHP, further evaluation and site-specific analysis will be required to fully determine their NRHP status and potential impacts. Based on the uncertainty of site-specific conditions, all sites located in or within 1 mi of a corridor could be vulnerable to visual impacts. To date, no Native American traditional, religious or sacred sites have been identified, and none are anticipated.

The principal project actions for the transmit powerlines include construction of up to 548 powerline structures. Ground disturbance would affect up to 5 acres within the selected powerline routes. Any significant archeological sites currently recorded or discovered within the area of ground disturbance could be damaged or destroyed by equipment used in the placement of poles. Significant historic structures currently recorded or discovered within any of the links could be visually affected by construction of the powerlines. Native American traditional, religious, or sacred sites identified in or near the sites could also be visually affected. Human burial sites

occurring within the area of ground disturbance could be damaged. The presence of construction personnel unfamiliar with regulations governing cultural resources on federal property could result in impacts caused from uncontrolled collection of cultural artifacts or damage to an archeological or architectural site.

The potential for these impacts is analyzed on a link-by-link basis below:

Link 1 contains a total of 74 architectural structures, 62 of which are located within two historic districts in Groton, South Dakota while 8 are in Claremont, South Dakota. Three additional sites are located in Groton, and one more north of the city limits. Two sites are currently listed on the NRHP; the remaining 72 are potentially eligible. All could be subject to visual impacts.

Link 2 contains no recorded archeological sites or historic structures; however, Link 2 has high potential for prehistoric archeological sites because it includes many water features.

Link 3 contains two recorded historic archeological sites associated with the old Columbia Trail bordering Link 5. If determined eligible for inclusion on the NRHP, visual impacts could result.

Link 4 contains no recorded archeological sites or historic structures. It would have a high potential for prehistoric archeological sites because of the number of water features within the link.

Link 5 contains the two recorded historic archeological sites described for Link 3. No historic structures are recorded in Link 5.

Link 6 contains no recorded archeological sites or historic structures.

Link 7 contains two recorded prehistoric/historic archeological sites, one potential historic archeological site, and two recorded historic architectural sites. If eligible for inclusion on the NRHP, the three archeological sites could be damaged or destroyed during powerline construction. The historic structures could sustain visual impacts. Link 7 also has higher potential for prehistoric archeological sites because of the number of riparian features.

Link 8 contains three recorded historic architectural/archeological site leads. The sites could sustain damage during powerline construction, or if eligible for listing on the NRHP visual impacts.

Link 9 contains two recorded rural historic architectural/archeological site leads, and two recorded urban historic architectural sites in the Havana, North Dakota. If eligible for listing on the NRHP, the sites could sustain damaged or destroyed during ground-disturbing activities. Link 9 also has the highest potential for prehistoric archeological sites due to the numerous wetlands occurring within the link.

Link 10 contains two recorded historic architectural sites and one historic architectural/archeological site lead located in Forman, North Dakota. One site is listed on the NRHP. If the remaining two are eligible for inclusion on the NRHP, all sites could sustain visual impacts. The archeological site could also be damaged by construction activities.

4.13.4.2 Receive Site

Based on the results of background research and consideration of physiographic features, prehistoric archeological resource potential for the proposed receive powerline corridors is high. Areas of high resource potential are located along the beach ridge areas of glacial Lake Agassiz, and along rivers, streams, and marshlands. The potential for identifying additional significant historic structures is moderate. Approximately two rural structures per mile of powerline corridor are anticipated, and additional urban historic structures could occur in Radium.

Potential impacts are anticipated for 4 of the 6 recorded sites identified during the records search. To date, no Native American traditional, religious, or sacred sites have been identified, although as previously noted, a member of the Devils Lake Sioux Tribe has mentioned a possible site located somewhere between Thief River Falls and Crookston.

Construction of the receive powerline corridors could require installation of about 87 wooden poles for the Radium Substation corridor, or up to 282 wooden poles for the Dakota-Junction or

Morris-Owen corridors. Additionally, all of part of the transmission lines would be buried. Ground disturbance would occur over less than 27 acres for any of the four corridors.

Archeological sites occurring within the area of ground disturbance could be damaged or destroyed by heavy equipment used for installation of poles or burying of the transmission lines. Additionally, significant historic structures and Native American traditional, religious, or sacred sites located within any of the links could be significantly visually affected by construction of the overhead powerlines. Human burial sites discovered within the area of ground disturbance would be destroyed. The presence of construction personnel unfamiliar with regulations governing cultural resources on federal property could also result in impacts caused from uncontrolled collection of cultural artifacts or damage to an archeological or architectural site.

Morris Owen Corridors—Construction of a powerline within either of the corridors connecting to the Morris-Owen substation could result in visual impacts to the first house in Pennington County, the Lanstad Church, and the Norden Church, if they are eligible for inclusion on the NRHP and if their eligibility is related to their setting. Further evaluation is required to fully determine their status. Depending on NRHP eligibility, the recorded and unrecorded portions of the Woods/Pembina Historic Trail located in the western section of the eastern CSA could be affected by construction of the powerlines. For either corridor connecting to that substation, the powerlines would probably be placed underground where it crosses the trail because it is within one-quarter mile of the preliminary site layout. Trenching for that line could physically disturb a small portion of that trail. Resource potential is very high for archeological sites along the four glacial Lake Agassiz beach ridges (See Figure 4.13.1). Significant cultural resources are anticipated along those sensitive areas.

Dakota Junction Corridor—The Dakota Junction Substation contains no recorded sites along the corridor. However, the corridor would cross the Woods/Pembina Historic Trail in the western portion of the eastern CSA, and impacts due to trenching for underground installation of the line would result. Resource potential is very high for archeological sites along the five glacial

Lake Agassiz beach ridges and the Thief River. Significant cultural resources are expected to occur at those sensitive areas.

Radium Corridor—The Radium Substation contains no recorded archeological sites or historic structures. However, resource density for prehistoric archeological sites is expected to be high along the Snake River and the South Branch of the Snake River.

4.13.5 Mitigation Measures

The following mitigation measures are intended to reduce effects on cultural resources from construction and operation of the CRS. Implementation of measures M4.13.1, M4.13.2, M4.13.3, M4.13.6, and M4.13.8 would be required to prevent significant impacts on cultural resources.

4.13.5.1 General Measures

M4.13.1 - If possible, avoid siting CRS facilities where there are historic properties that are eligible or potentially eligible for inclusion in the NRHP. This may require realigning access roads and relocating detention basins, water wells, drainage channels, and the like. Site avoidance would eliminate significant physical impacts to cultural resources.

M4.13.2 - If NRHP-eligible sites cannot be avoided, mitigation through preconstruction data recovery, analysis, and reporting of resource data may be required to prevent physical destruction, burial, or covering by structures.

M4.13.3 - If avoidance of an NRHP-eligible historic structure or archeological site cannot be avoided and its eligibility is related to its setting, consult with the appropriate SHPO. The following measures could be implemented, in consultation with the appropriate SHPO, to reduce or eliminate impacts.

- Screen visual effects with a vegetation buffer

- Move the historic structure to another location

- Record and document the historic property prior to demolition in accordance with applicable laws and standardized procedures. Records will be deposited in the Library of Congress or with an appropriate designated agency.

M4.13.4 - Avoid developing new gravel sources by using existing commercial borrow pits if feasible.

M4.13.5 - Develop procedures in consultation with Native American groups and the SHPOs to reduce or eliminate visual impacts on any identified traditional, religious, or sacred sites. Site avoidance is the preferred measure; however, buffering of visual effects or ceremonial actions could apply.

M4.13.6 - Avoid construction at human burial sites. If this is not possible, uncovered human remains should be treated as follows:

- South Dakota: Consult with the SHPO in conjunction with appropriate Native American tribes to determine the course of action.
- North Dakota: Comply with the procedures specified in North Dakota Century Code (NDCC) 23-06-27 and Draft 5 of Administrative Rule 40-02-03. Upon discovery, immediately notify the SHPO and initiate consultations with the Reinternment Committee of the North Dakota Indian Affairs Committee.
- Minnesota: Halt construction immediately and contact the Minnesota Office of the State Archeologist (OSA). Coordinate subsequent development actions at the burial site are to be coordinated with the OSA in consultation with appropriate Native American tribes.

M4.13.7 - To prevent unnecessary physical damage or destruction, place protective barriers around significant resources at construction sites.

M4.13.8 - To ensure that cultural resources discovered during construction are afforded timely and appropriate mitigation, develop and implement procedures to monitor construction activities and recover data or protect resources discovered during construction.

M4.13.9 - Conduct a pre-construction training program for construction supervisors that includes instruction on the types of cultural resources that may be discovered at a particular location, identification of resources during construction, and procedures to follow if resources are discovered.

M4.13.10 - To reduce unauthorized artifact collection and damage to cultural resources, conduct an orientation program for construction and operations personnel to familiarize them with federal regulations governing cultural resources and legal penalties for collection of and damage to cultural resources on federal property.

M4.13.11 - To ensure proper implementation of the CRS CRMP, assign appropriate staff from the Tactical Air Command as CRMP administrator.

4.13.5.2 Applicable to Tx-N and Tx-S

M4.13.12 - Mitigation measure M4.13.1 would eliminate impacts to prehistoric and historical archeological sites. If prehistoric sites cannot be avoided, M4.13.2 would eliminate impacts. If historical sites cannot be avoided, M4.13.3 would apply

M4.13.13 - Mitigation measure M4.13.1 will eliminate potential impacts to the Swenson and Johnson homesteads. If the sites cannot be avoided, M4.13.3 would apply. Those sites may sustain unmitigateable significant impacts..

4.13.5.3 Applicable to Rx-E

M4.13.14 - Measure 4.13.1 or 4.13.3 listed above must be applied to the Woods/Pembina Trial to prevent or reduce visual impacts. Even with application of mitigation measures, significant impacts could result.

4.13.5.4 Applicable to Powerlines

M4.13.15 - Link 1: Impacts to the 74 historic architectural structures in Link 1 would be eliminated with the application of mitigation measure M4.13.1. If sites cannot be avoided, M4.13.3 applies.

M4.13.16 - Links 3 and 5: Impacts to the two Columbia Trail sites could be eliminated with the application of mitigation measure M4.13.1. If the sites cannot be avoided, measures M4.13.2 or M4.13.3 would be applied.

M4.13.17 - Links 7-10: Impacts to the 15 cultural resource sites in Links 7-10 would be precluded with the application of mitigation measure M4.13.1. If the three archeological sites in Link 7 cannot be avoided, measure M4.13.2 would apply. Application of M4.13.2 or M4.13.3 to the historic architectural/archeological sites in Links 8, 9 and 10 may be required. Application of M4.13.3 to the historic architectural sites in Links 7, 9, and 10 may be required.

M4.13.18 - To minimize impacts on the Woods/Pembina Trail and other historic properties near the Rx-E powerline, measures 4.13.1 and 4.13.3 should be applied.

4.14 IRRETRIEVABLE COMMITMENT OF RESOURCES

Construction of the Central Radar System (CRS) will require the use of nonrenewable resources such as fuels, construction materials, and land. Heavy equipment and haul trucks will use diesel fuel and gasoline during the construction period. During CRS operation, employees commuting to the sites and maintenance and security personnel moving about the site will burn much smaller quantities of fuel. Additionally, generating electricity for CRS will require consumption of some type of fuel, probably coal, the fuel most commonly used for electric generation in the region. Because fossil fuels are non-renewable, the increase in fuel consumption

attributable to CRS will be irreversible. However, the amount of fuel consumed during CRS construction and operation will be a small fraction of the total amount of fuel consumed in the region and nation.

Construction materials used to build the CRS include gravel for the groundscreen bases and for surfacing roads; aggregate, sand, cement, and water to form concrete; sand to backfill utility trenches; metals for structural frames, building sidings, radiating elements, and powerline conductors; and wood for powerline structures, building parts, and fencing. Except for wood, all of those materials are nonrenewable. Therefore, the project will contribute, in a small measure, to depletion of local resources of those materials. As for fuel use, however, the amount of construction materials consumed will be inconsequential when compared with regional and national consumption.

The CRS transmit and receive facilities will occupy as many as 2,600 acres for a construction period of up to 5 years and an operation period of 20 yr or more. Activities will be restricted on powerline ROWs. The 2,600 acres used for antenna siting will be removed from agricultural use and will be relatively inaccessible, as well as undesirable, to wildlife. The amount of farmland that will be removed from production represents much less than 1% of the total farmland of the counties in which the CRS transmit and receive sites are located. The loss in farm product output will be insignificant. From a wildlife habitat standpoint, the wetlands at the CRS sites are the most significant areas in terms of vegetative productivity and wildlife foraging and habitation. The Air Force is committed to replacing the wildlife value of those wetlands through off-site mitigation, resulting in no net loss of wetlands. Thus, the temporary use of land by CRS will be an insignificant commitment of that resource.

4.15 LONG-TERM PRODUCTIVITY OF THE LAND

The Central Radar System will consist of eight antenna sectors (four transmit and four receive sectors) at two locations in the northern Great Plains. Depending on the site chosen and the final layout of facilities, the total land required for the CRS transmit facilities could range up to 2,600 acres. Physical disruption from construction, however, would affect only as many as 511 acres. The majority of the acquired land will be within the exclusion area, and will not be physically disturbed.

The productivity of the land for wildlife stems from the habitat and forage areas it provides. Both of the alternative transmit-site layouts include wetlands that provide the most important type of habitat and foraging grounds in the area. This EIS recommends, and federal regulations for wetland-filling permits require, that any wetlands that are filled be replaced by restoration, creation, or enhancement of an equal amount of wetlands of similar quality. The Air Force is committed to that mitigation measure; its implementation will result in no net loss of wetlands. During construction and operation, several hundred acres of upland will also be removed from wildlife use. Much of that land is currently cultivated, however, and has less value than the wetlands have for wildlife. Given the large upland areas in the vicinity, the temporary removal of that acreage from possible wildlife use will be a minor impact. After decommissioning, the CRS structures will be removed, and the land could revert to its existing condition.

The project will remove up to 2,600 acres from agricultural use in Marshall County and possibly in Brown County. Much of that land will be usable for agriculture when CRS is decommissioned in approximately 25 years. The majority of that land will not be physically disrupted, and its agricultural productivity is not expected to decline. However, the construction areas, about 511 acres, may be greatly diminished in agricultural value. Because construction areas represent less than 0.01% of the 500,000 acres of agricultural land in Marshall County, loss of its agricultural productivity would be a negligible impact. (Schultz, 1975)

The CRS receive facilities will require as many as 1,000 acres in Polk or Pennington County, Minnesota. Only about 527 acres will, however, actually be physically disrupted by construction of buildings, roads, and other facilities. As with the transmit site, the most ecologically valuable portions of the site are the wetlands, and their loss will be mitigated by restoration or creation of an equal amount of wetlands. The temporary loss of upland during project construction and operation will be a minor impact because most uplands are farmed, and large areas of upland occur in the area. Impacts on wildlife values will be small.

Up to 1,000 acres will be temporarily removed from agricultural use in either Polk or Pennington County. After CRS decommissioning, much of that land could return to agricultural use. The value of areas directly affected by construction, however, may be diminished as a result of removal of topsoil and compaction of the subsoil. Those areas would require new topsoil and other improvements to return to full productivity. Because construction would occur on only as many as 527 acres, which is about 0.3% of the total cropland acreage in Pennington County alone, that would be an insignificant impact.(Heschke, 1984)

The power transmission lines and substations for the CRS transmit and receive sites will occupy substantial portions of land. The ROW area is estimated at 1,270 acres for the transmit-site powerlines and 100 acres for the receive-site powerlines. An additional 0.5 acre of land will be needed for expansion of the Groton and Forman substations. Most of the land for the powerline ROWs would be usable for agriculture after powerline construction. Only about 6 acres beneath towers and at the substation expansions will be unusable as a result of building the transmit site powerline. The receive site powerline would render no more than 2 acres unusable for agriculture. The temporary commitment of that land to CRS would be insignificant.

The project will decrease the long-term productivity of about 500 acres of land at both the transmit and receive sites. The loss of wildlife habitat and foraging areas will be partially offset by mitigation for wetland filling that will result in no net loss of wetland. The vast majority of the site

areas will be available for agricultural use after project decommissioning, and only small portions of the sites will have lower agricultural value. For those reasons, the CRS will not have significant impact on the long-term productivity of the transmit or receive sites or the powerline ROWs.

4.16 CUMULATIVE IMPACTS

The alternative sites for the CRS transmit and receive facilities and alternative powerline corridors are located in a rural agricultural portion of the upper Midwest. Between 1980 and 1988, the counties in the socioeconomic study area for both the transmit and receive sites have declined in population by 0.2-9.3% (see section 3.10). There is very little urban development or infrastructure improvement proposed, planned, or under construction in the area, other than the CRS. The potential for non-CRS development to cumulatively add to the level of impact on natural resources, including soils, permanent water bodies, air, or the biosphere, is very low. Cumulative effects are possible on wetlands, which have decreased in number and area over the past few decades due primarily to draining and conversion to agricultural use. Recently, concern has been expressed about the loss of wetland nationwide, and in particular in the prairie pothole region that includes the CRS sites. As a result, the federal government has established a policy of no net wetland loss. During construction of CRS, the Air Force plans to fully mitigate CRS impacts on wetlands through restoration of existing degraded wetlands, creation of new wetlands, or contributions to existing programs to achieve the same (see sections 4.7.1.2, 4.7.2.2. and 4.7.4).

Because of the declining population of the CRS study area, the likelihood of cumulative impacts on the human environment is very low. There are no known major developments planned in the vicinity of the alternative CRS sites which could result in cumulative impacts, in addition to those from the CRS, on visual aesthetics, land use, recreational opportunities, employment and housing, transportation, or cultural resources. The predominant land use of the study areas will remain agricultural after CRS development and for the foreseeable future. CRS may cause a temporary influx of construction workers and a much smaller influx of permanent employees

during system operation, but the population of the affected counties would still be level or would decline slightly as has been the recent trend. The Minnesota and South Dakota departments of transportation project little or no increase in traffic volumes at the study areas in the near future, other than that resulting from the CRS. There will be no substantial cumulative impact on local roads.

5. LIST OF PREPARERS

SRI International of Menlo Park, California, prepared this EIS under contract to the U.S. Air Force Electronic Systems Division (ESD). Metcalf & Eddy/Holmes & Narver of Wakefield, Massachusetts, prepared technical studies on the Environmental Impact Analysis Process (EIAP), facilities, transportation, hydrology and water quality, vegetation, wetlands and aquatics, mammals, avian studies, threatened and endangered species, and powerline biological resources under a separate contract with ESD. Those technical reports are summarized in the EIS. In addition, SRI hired several subcontractors and consultants to conduct environmental studies including Environmental Science Associates, Inc., San Francisco, California (air quality and noise analysis); the University of North Dakota, Grand Forks, North Dakota (cultural resources investigations); Hammon, Jensen, Wallen & Associates, Oakland, California (wetland and land use mapping of powerline corridors); Marilyn Duffey, San Francisco, California (visual analysis); Dr. Peter Polson, Cupertino, California (powerline field bioeffects); and Mr. Louis Heynick, Palo Alto, California (radiofrequency radiation bioeffects). The scientists who worked on this EIS and their qualifications are listed by firm below.

Sidney Everett, Ph.D., environmental analysis, Stanford University; 17 years experience in environmental impact assessment and project management. Dr. Everett was the EIS Project Supervisor.

James Manitakos, Jr., M.A., geology, University of California at Berkeley; 6 years experience in environmental analysis and project management. Mr. Manitakos was Project Leader for preparation of the EIS and prepared the sections on Purpose and Need for the Action, Project and Alternatives Description, and analysis of geological and hydrological impacts (Sections 1, 2, 3.1, 3.2, 4.1, 4.2, and 5) for this EIS.

William Edson, Dr. Sc., electrical communications, Harvard University; 52 years experience in electrical engineering. Dr. Edson analyzed electromagnetic interference (EMI) for the technical report on EMI and radiofrequency and extremely low frequency radiation bioeffects, which are summarized in Sections 3.5 and 4.5.

Buford Holt, Ph.D., botany and plant pathology, Michigan State University; 20 years experience in environmental analysis. Dr. Holt prepared sections analyzing impacts on biological resources (Sections 3.6 and 4.7).

Paul Kroupa, B.A., economics, St. Mary's College; 5 years experience in economic analysis. Mr. Kroupa assisted in the preparation of the analysis of land use, socioeconomics, and recreation (Sections 3.8, 3.9, 3.10, 4.9, 4.10, and 4.11).

Jeannette Nishida, B.A., social sciences, San Jose State University; 4 years experience in environmental analysis. Ms. Nishida assisted in the investigation of effects on cultural resources (Section 3.12 and 4.13).

John Ryan, M.B.A., Santa Clara University; 24 years experience in economic analysis. Mr. Ryan assisted in preparation of the analysis of land use, recreation, and socioeconomics effects (Sections 3.8, 3.9, 3.10, 4.9, 4.10 and 4.11).

Consultants to SRI International

Marilyn Duffey; M.S., cybernetics systems, San Jose State University; 18 years experience in environmental and visual analysis. Ms. Duffey analyzed visual resources and impacts (Sections 3.7 and 4.8).

Louis Heynick, M.S., physics, New York University; 27 years experience in electrical engineering and health effects of nonionizing electromagnetic fields. Mr. Heynick assisted in the

preparation of the technical report on EMI and radiofrequency radiation and powerline field bioeffects.

Peter Polson, Ph.D., brain research, University of Adelaide; 18 years experience in biomedical engineering. Dr. Polson assisted in the preparation of the technical report on EMI and radiofrequency and powerline field radiation bioeffects.

Environmental Science Associates

Claire Chapin, Ph.D., engineering, Purdue University; 15 years experience in analysis of gas dynamics and fluid flow. Dr. Chapin assisted in the analysis of air quality and noise impacts (Sections 3.3, 3.4, 4.3, and 4.4).

Bruce Campbell, B.S., environmental biology, University of California at Santa Barbara; 16 years experience in air quality, noise, and energy analysis. Mr. Campbell assisted in the analysis of air quality and noise impacts (Sections 3.3, 3.4, 4.3, and 4.4).

University of North Dakota

Michael Gregg, Ph.D., anthropology, University of Wisconsin at Milwaukee; 19 years experience in anthropological and archeological research. Dr. Gregg was Project Manager for preparation of the Cultural Resources Technical Report, which is summarized in Sections 3.12 and 4.13.

Dennis Toom, M.A., anthropology, University of Nebraska at Lincoln; 16 years experience investigating the prehistoric and historic archaeology of the Northern Plains, Central Plains, and Southwest. Mr. Toom assisted in the preparation of the Cultural Resources Technical Report, which is summarized in sections 3.12 and 4.13.

Paul Picha, B.A., anthropology, Hamline University; 14 years experience in prehistoric and historic archeology of the Great Plains. Mr. Picha assisted in the preparation of the Cultural Resources Technical Report.

Hammon, Jensen, Wallen & Associates

David DeVries, B.S., soil resource management, University of California at Berkeley; 11 years experience in remote sensing, soil science, and environmental analysis. Mr. DeVries assisted in the analyses of hydrology and water quality and land use for the power supply corridors.

Robert Shanks, M.A., geography, University of California at Santa Barbara; 4 years experience in application of geographic information systems to environmental analysis. Mr. Shanks assisted in the analyses of hydrology and water quality and land use for the power supply corridors.

Metcalf & Eddy/Holmes & Narver

Dominique N. Brocard, Metcalf and Eddy, Inc., Ph.D., civil engineering, Massachusetts Institute of Technology; 14 years experience in modeling and analysis of groundwater flow and contamination, water quality, and hydraulics. Dr. Brocard reviewed and contributed to Technical Study 4, Hydrology/Water Quality.

Karen D. Bush, Holmes & Narver, Inc., B.S., wildlife biology, University of Massachusetts; 2 years experience in field biology. Ms. Bush prepared Technical Study 5, Vegetation.

Elaine L. Cappucci, Metcalf and Eddy, Inc., M.E.M., natural resource ecology, Duke University; 4 years experience in environmental planning, monitoring, and analysis. Ms. Cappucci was task leader for preparation of the Technical Studies and reviewed and contributed to

each. Ms. Cappucci also prepared Technical Study 1, Environmental Impact Analysis Process Overview.

Andrew R. Cutko, Metcalf & Eddy, Inc., M.F., forest ecology, Duke University; 3 years experience in ecological analysis and environmental planning. Mr. Cutko contributed to Technical Study 6, Wetlands and Aquatics, and prepared Technical Study 9, Threatened and Endangered Species, and 10, Powerline Biological Resources.

Jennifer A. Doyle, Homes & Narver, Inc., B.A., biology, Holy Cross University; 1 year experience in biology and technical writing. Ms. Doyle coauthored Technical Study 7, Mammals.

Marlo S. Engel, Metcalf & Eddy, Inc., M.R.P., regional planning, University of North Carolina; 6 years experience in land use, transportation, and environmental planning. Ms. Engel prepared Technical Study 3, Transportation.

Carlos M. Ferreira, Metcalf & Eddy, Inc., B.S., civil engineering, University of Rhode Island; 1 year experience in transportation and utility engineering. Mr. Ferreira prepared the sections on water supply, waste disposal, and utilities for Technical Study 2, Facilities.

William B. Kappleman, Metcalf and Eddy, Inc., M.S. (candidate), wildlife biology, University of Vermont; 3 years experience in environmental monitoring and assessment of avian resources. Mr. Kappleman prepared Technical Study 8, Avian Resources.

Donald M. Kent, Metcalf & Eddy, Inc., Ph.D., ecology, evolution, and behavior, Boston University; 8 years experience in environmental evaluations and wetlands delineation, functional analysis, restoration, and creation. Dr. Kent reviewed Technical Studies 5, Vegetation, 6, Wetlands and Aquatics, and 9, Threatened and Endangered Species.

Tinny H. Lee, Metcalf & Eddy, Inc., M.S., environmental engineering, University of Florida; 13 years experience in water, wastewater, and drainage systems design and water sample analysis. Ms. Lee reviewed and contributed to Technical Study 4, Hydrology and Water Quality.

James T. Maughan, Metcalf and Eddy Inc., Ph.D., biological oceanography, University of Rhode Island; 16 years experience in environmental studies, evaluations, and permitting. Dr. Maughan was the Technical Study project manager and reviewed and contributed to all the technical studies.

Kevin R. McManus, Metcalf and Eddy, Inc., M.A., marine resource management, University of Washington; 6 years experience in environmental planning, assessment, protection and regulations. Mr. McManus reviewed and contributed to all the Technical Studies.

Stephen E. Petron, Metcalf and Eddy, Ph.D., zoology, Washington State University; 4 years experience in environmental study and evaluation of ecological terrestrial resources. Dr. Petron reviewed the technical studies and coauthored Technical Study 7, Mammals.

Susan M. Savoie, Holmes & Narver, Inc., B. A., Queens University; 5 years experience in aquatic biology. Ms. Savoie prepared Technical Study 6, Wetlands and Aquatics.

Karin J. Shepardson, Metcalf & Eddy, Inc., M.S., civil engineering and urban and environmental policy, Tufts University; 2 years experience in water resources engineering, environmental analysis, and permitting. Ms. Shepardson prepared Technical Study 4, Hydrology and Water Quality.

Louis M. Taverna, P.E., Metcalf & Eddy, Inc., M.S.C.E., civil engineering, Massachusetts Institute of Technology; 11 years experience in civil, geotechnical, and military facilities engineering. Mr. Taverna reviewed and contributed to Technical Study 2, Facilities, and reviewed Technical Studies 3, Transportation, and 4, Hydrology and Water Quality.

Charles G. Tiersch, P.E., Metcalf & Eddy, Inc., B.S., civil engineering, New York University; 36 years experience in planning, design, and construction management of civil and military projects. Mr. Tiersch prepared Technical Study 2, Facilities.

Martha L. Zirbel, P.E., Metcalf & Eddy, Inc., M.S., agricultural engineering, University of Minnesota; 8 years experience in hydrology, soil conservation, and remedial investigations. Ms. Zirbel prepared the sections on prime farmlands in Technical Study 5, Vegetation.

6. EIS DISTRIBUTION LIST

Federal, State, and Local Officials

Senator Rudy Boschwitz
Room 210, Bremer Bldg.
St. Paul, MN 55101

Senator Quentin N. Burdick
Federal Building 1
Bismarck, ND 58501

Robert Carlson, Mayor
City of Thief River Falls
Box 528
Thief River Falls, MN 56701

Mayor, City of Warren
City Clerk's Office
126 W. Johnson
Warren, MN 56762

Senator Kent Conrad
Room 228, Federal Bldg.
3rd Street and Rosser Avenue
Bismarck, ND 58501

Senator Thomas A. Dashle
P.O. Box 1536
Aberdeen, SD 57401-1536

Rep. Byron L. Dorgan
P.O. Box 2579
Bismarck, ND 58502-2579

Senator Dave Durenberger
1020 Plymouth Building
12 S. 6th Street
Minneapolis, MN 55402

Delores Henehan, Mayor
City of Britton
P.O. Box 91
Britton, SD 57430

Rep. Tim Johnson
615 S. Main
P.O. Box 1554
Aberdeen, SD 57401

Governor George S. Mickelson
500 East Capital
Pierre, SD 57501

Governor Rudy Perpich
130 State Capital
St. Paul, MN 55155

Senator Larry Pressler
224 East Capital
Pierre, SD 57501

Honorable George A. Sinner
600 East Boulevard
Bismark, ND 58501-0001

Rep. Arlan Stangeland
403 Center Avenue
Moorhead, MN 56560-1991

Lloyd Trautman, Mayor
City of Hecla
P.O. Box 188
Hecla, SD 57466

Federal, State, and Local Natural Resources Planning Agencies and Organizations

Director
Agassiz Audubon Society
Route 2, Box 45A
Warren, MN 56702

Refuge Manager
Agassiz National Wildlife Refuge
Middle River, MN 56737

Refuge Director
Agassiz National Wildlife Refuge
RR 1
Middler River, MN 56737

Nina Archibald
State Historic Preservation Officer
Minnesota Historical Society
690 Cedar Street
St. Paul, MN 55101

Cary Backstrand
Chief, Regulatory Section
ND Water Commission
900 E. Boulevard
Bismarck, ND 58501

Thomas Balcom
Office of Planning
Minnesota Department of Natural Resources
500 Lafayette Road
St. Paul, MN 55146

Area Director, Aberdeen Area
Bureau of Indian Affairs
U.S. Department of the Interior
115 – 4th Avenue, South East
Aberdeen, SD 57401

Area Director, Minneapolis Area
Bureau of Indian Affairs
U.S. Department of the Interior
15 South Fifth Street
Minneapolis, MN 55402

Director
Chamber of Commerce
P.O. Box 514
Thief River Falls, MN 56701

City Clerk's Office
City of Thief River Falls
Box 528
Thief River Falls, MN 56701

City Planner
City of Thief River Falls
Box 528
Thief River Falls, MN 56701

Chairman, Day County Commission
Route 1, Box 2
Bristol, SD 57219

County Auditor's Office
Day County
710 W. First
Webster, SD 47274

Commissioner
Department of Energy and
Economic Development
150 East Kellog Boulevard
St. Paul, MN 55101

Gregg Downing
MN Environmental Quality Board
110 Capitol Square Building
550 Cedar Street
St. Paul, MN 55101

Shirley Dykshoorn, Director
Office of Intergovernmental Assistance
14th Floor
State Capitol Building
Bismarck, ND 58501

East Grand Forks Town
Clerk's Office
303 NW 4
E. Grand Forks, MN 56721

Craig Faanes
U.S. Fish and Wildlife Service
Federal Building, 2nd Floor
203 W. Second Street
Grand Island, NE 68801

Regional Director, Great Lakes
Region
Federal Aviation Administration
2300 East Devon Avenue
Des Plaines, IL 60018-4686

First District Association of Local
Government
P.O. Box 1207
Watertown, SD 57201

Dr. Junius Fishburne
State Historic Preservation Officer
P.O. Box 417
Vermillion, SD 57069

Bill Franz
Regional EIS Coordinator
U.S. Environmental Protection Agency
230 South Dearborn Street
Chicago, IL 60604

Grand Forks County Planning Department
404 2nd Avenue N.
Grand Forks, ND 58202

Richard J. Gross
Governor's Council
Governor's Office
Capitol Building
Bismarck, ND 58505

Bruce Hagan, Commissioner
ND Public Service Commission
State Capitol
Bismarck, ND 58505

Mike Hammer
Environmental Policy Branch
U.S. Environmental Protection Agency
One Denver Place
999 18th Street
Denver, CO 80202-2413

Executive Director
Headwaters Regional Development
Commission
722 - 15th Street, NW, Box 906
Bemidji, MN 56601

Mavis Hogen
Secretary of Agriculture
Anderson Building
Pierre, SD 57501

Lloyd Jones
Commissioner
ND Game & Fish Department
100 N. Bismarck Expressway
Bismarck, ND 58501-5095

Ron Kennedy, Manager
Red Lake Electric Coop, Inc.
P.O. Box 430
Red Lake Falls, MN 56750

John Kirk
Interagency Coordinator
SD Game, Fish & Parks Department
445 E. Capitol Avenue
Anderson Building
Pierre, SD 57501

Director
Kulm Wetland Management District
P.O. Box E
Kulm, ND 58456

Director
Lake Agassiz Regional Planning Coun
321 North 4th
Fargo, ND 58102

Robert Marily
Water Quality Division
Environmental Protection Agency
1 Denver Place, Suite 500
999 - 18th Street
Denver, CO 80200

Commissioner
Minnesota Department of Agriculture
90 Plato Boulevard
St. Paul, MN 55107

Commissioner
Minnesota Department of Natural Resources
500 Lafayette Road
St. Paul, MN 55146

Commissioner
Minnesota Department of Transportation
Transportation Building
John Ireland Boulevard
St. Paul, MN 55155

Director
Minnesota Historical Society
Historical Building
690 Cedar Street
St. Paul, MN 55101

Executive Director
Minnesota Pollution Control Agency
1935 West County Road B2
Roseville, MN 55113

State Planning Director
Minnesota State Planning Agency
100 Capitol Square Building
550 Cedar Street
St. Paul, MN 55101

Alan Mitchell
Asst. Attorney General
Minnesota Attorney General's Office
520 Lafayette Road
St. Paul, MN 55155

Chief Environmental Health
North Dakota Health Department
1200 Missouri Avenue
Box 5520
Bismarck, ND 58502–5520

Natural Resources Coordinator
North Dakota Parks and Recreation Dept.
1424 W. Century Avenue, #202
Bismarck, ND 58501

Director, Administrative Services Div.
North Dakota State Highway Dept.
600 East Boulevard
Bismarck, ND 58505

North East Council of Governments
405 Eighth Avenue, NW
Suite 201, Berkshire Plaza
Aberdeen, SD 57401

Executive Director
Northwest Regional Development Commission
425 Woodland Avenue
Crookston, MN 56716

Director
Office of Environmental Project Review
Department of the Interior
Room 4260, Interior Building
18th and C Streets, NW
Washington, D.C. 20240–0001

Office of Intergovernmental Assistance
Office of Management and Budget
14th Floor – State Capitol
Bismarck, ND 58505

Michael O'Keefe
U.S. Army Corps of Envineers
Regulatory Branch
1431 U.S. Post Office
St. Paul, MN 56105–1479

Director
Red River Regional Planning Council
P.O. Box 633
Grafton, ND 58237

Refuge Director
Sand Lake National Wildlife Refuge
Route 1, Box 25
Columbia, SD 57433

Allyn J. Sapa
State Supervisor
U.S. Fish and Wildlife Service
Wetland Habitat Office
1500 E. Capitol Avenue
Bismarck, ND 58501

Lloyd Scott
Office of the State Engineer
900 East Boulevard
Bismarck, ND 58505

Conservation Officer
SD Game, Fish and Parks Department
P.O. Box 106
Britton, SD 57430

Director
SD Public Utilities Commission
500 E. Capitol Avenue
Pierre, SD 57501

Soil Conservation Service
Room 324
Federal Office Building
102 N. 4th Street
Grand Forks, ND 58201

Director, South Central
Dakota Regional Council
P.O. Box 903
Jamestown, ND 58501

James Sperry
State Historic Preservation Officer
North Dakota Heritage Center
Bismarck, ND 58505

State Government Operations
State Capitol Building
Executive Office
Pierre, SD 57501

Chief of Operations
State Capitol Building
Pierre, SD 57501

Mark Steichen
Deputy Secretary
SD Department Water and Natural
Resources
Joe Foss Building
523 E. Capitol Avenue
Pierre, SD 57501

Jeff Stingley, Secretary
Department of Game, Fish and Parks
Anderson Building
445 E. Capitol Avenue
Pierre, SD 57501

Jim Suedkamp
U.S. Army Corps of Engineers
Regulatory Branch
Federal Building, Room 253
Pierre, SD 57501

Kevin Suhr, Planner
Northeast Council of Governments
405 Eighth Avenue, NW
Suite 201, Berkshire Plaza
Aberdeen, SD 57401

Refuge Director
Tewakon National Wildlife Refuge
RR 1, Box 75
Cayuga, ND 58013

Director, Brown County
U.S. Agricultural Stabilization and
Conservation Service
Box 729
Aberdeen, SD 57402

Director, Day County
U.S. Agricultural Stabilization and
Conservation service
Box 150
Webster, SD 57274

Director, Marshall County
U.S. Agricultural Stabilization and
Conservation Service
Box 420
Britton, SD 57430

Director, Marshall County
U.S. Agricultural Stabilization and
Conservation Service
105 S. Division
Warren, MN 56762

Director, Pennington County
U.S. Agricultural Stabilization and
Conservation Service
Thief River Falls, MN 56701

Director, Polk County
U.S. Agricultural Stabilization and
Conservation Service
P. O. Box 476
Crookston, MN 56716

Chief, Division of Environmental Coordination
U.S. Fish and Wildlife Service
U.S. Department of the Interior
Room 402, Hamilton Building
18th and C Streets, NW
Washington, DC 20240-0001

Regional Director, Region 3
U.S. Fish and Wildlife Service
U.S. Department of the Interior
Federal Building, Fort Snelling
Twin Cities, MN 55111

Regional Director, Region 6
U.S. Fish and Wildlife Service
U.S. Department of the Interior
Denver Federal Center
P.O. Box 25486
Denver, CO 80225

U.S. Forest Service
1824 North 11th Street
Bismarck, ND 58501

Robert Welford, State Supervisor
U.S. Fish and Wildlife Service
50 Park Square Court
400 Sibley Street
St. Paul, MN 55101

Jim Winters
State Supervisor
U.S. Army Corps of Engineers
Regulatory Branch
2400 University Avenue
Bismarck, ND 58504

M. S. Zscholmer, State Supervisor
P.O. Box 986
Pierre, SD 57501

Individuals

Raymond and Olga Anderson
Rt. 1, Box 36
Langford, SD 57454

Arthur and Lillie Asp
Rt. 1, Box 159
Thief River Falls, MN 56701

Jerry and Marie Bennett
2309 Nicolas Drive
Fullerton, CA 92633

Louis Carpenter
Rt. 1, Box 236
Thief River Falls, MN 56701

Roger Clarke
North States Power Company
414 Nicollet Mall
Minneapolis, MN 55401

Ricky D. Cole
Rt. 1, Box 43
Langford, SD 57454

Sylvia Ann Cutler and
Mary Lynn James
Rt. 1, Box 19
Houghton, SD 57449

Donald Diedrich
Rt. 3, Box 2
Warren, MN 59762

Dinger Hereford Ranch, Inc.
Attn: William Dinger
RR 1, Box 93
Hecla, SD 57446

Joseph and Patricia Donovon
Rt/ #1, Box 130
Hecla, SD 57446

Donavan Dyrdal
Route 1, Box 216A
Thief River Falls, MN 56701

James Edgar
623 E. Calvin Avenue
Warren, MN 59762

Connie Eizen
2625 Cowley
San Sigo, CA 92110

Clarence and Margaret Erickson
Rt. 3, Box 144
Groton, SD 57445

Robert and Imogene Erickson
Rt. 1, Box 91
Langford, SD 57454

Farm Credit Services
Attn: Del Lowe
P.O. Box 1987
Aberdeen, SD 57402-1987

Herbert and Arlene Foote
Rt. 1, Box 37
Claremont, SD 57432

Cunhild and Chester Hanson
Rt. 1, Box 39
Claremont, SD 57432

Rith Hanson
Rt. 1, Box 38
Claremont, SD 57432

Reuben and Genevieve Hermann
Rt. 1, Box 33
Langford, SD 57454

Al Hermodson
Route 3, Box 68
Crookston, MN 56716

Warren and Mary Ann Hermreck
Rt. 1, Box 143
Thief River Falls, MN 59701

Genevieve Hupke
Box 93
Langford, SD 57454

Ronald R. Jarrett
RR 2, Box 179
Britton, SD 57430

Donnell and Donna Johnson
10557 Decatur Avenue, South
Bloomington, MN 55438

Edna Scott Johnson
110 Elizabeth Drive
Aberdeen, SD 57401

John W. Johnson
Rt. 3
Warren, MN 56762

Lori D. Johnson and Clark Bennett
9471 Queen Oak Court
Elk Grove, CA 95624

Daphne Kinzler
Box 16
Oakes, ND 58474

Knecht Farms, Inc.
Attn: Randy Knect
Houghton, SD 57449

Winton Knutson
Rt. 1, Box 129
Thief River Falls, MN 59701

Ruby Lamberton
126 South 1st Street
Webster, SD 57214

Thomas Landreth
Rt. 1, Box 151
Britton, SD 57430

Edna C. Olson Laymon
8241 – 5th Avenue South
Bloomington, MN 55420

Larry Laymon
Rt. 2
Warren, MN 56762

Marvin Lehr
RR 2, Box 19
Britton, SD 57430

Donavon C. Loeslie
Rt. 1, Box 25
Warren, MN 56762

Kipp S. Loeslie
522 Warren Div.
Warren, MN 56762

Leslie Malm
Rt. 1, Box 29
Langford, SD 57454

Merlyn Miller
Rt. 2, Box 24
Wahpeton, ND 58075

Evelyn Nelson
Rt. 1, Box 35
Langford, SD 57454

John L. Nelson
Rt. 1, Box 152
Thief River Falls, MN 56701

Jeanne and Sylvester Novak
Rt. 2
East Grand Forks, ND 56721

Daniel Olson
c/o Inez Lindquist Olson
RR 2, Box 32
Groton, SD 57445

Frank Lynn Olson
16422 – 152nd Avenue, NE
Brush Prairie, WA 98606

John K. Olson
154 Jacobson
Glendale Heights, IL 60139

Eldor and Stella Omdahl
Rt. 2, Box 45
Warren, MN 56762

John Omdahl
Rt. 2, Box 42
Warren, MN 56762

Berdolf C. Pederson
Warren, MN 56762

Jerome Quanrud
226 N. 4th Street
Warren, MN 56762

Weona and Dale Quist
Rt. 1, Box 27
Langford, SD 57454

Mr. and Mrs. David Reesenweber
RR 1, Box 130
Britton, SD 57430

Loretta Ringler
504 – 20th Avenue, NE
Aberdeen, SD 57401

Larry and Faith Rud
Rt. 3
Warren, MN 56762

Leslie and June J. Seward
Rt. 3
Warren, MN 56762

Carla Sims
5902 Twin Cities Road
Elk Grove, CA 95624

Charles and Donna Stehly
RR, Box 129
Hecla, SD 57446

Dale Stirling
Environmental Historian
Heritage North
11502 Phinney Avenue North
Seattle, WA 98133

Gladys Stromberg
Box 55
Newfolden, MN 56738

Sunset Hutterian Brethern, Inc.
Rt. 2, Box 159
Britton, SD 57430

Richard Symens
Rt. 1, Box 54
Claremont, SD 57432

Bonnie Thompson, President
Garrett Farms, Inc.
P.O. Box 497
Britton, SD 57430

Donald W. Tisher
Box 235
Amherst, SD 57431

D. Weiland
3611 – 18th Avenue, South
Grand Forks, ND 58201

Gregory and Helen Weiland
Rt. 1, Box 86
Euclid, MN 56722

Paul Williams
Rt. 1, Box 51
Langford, SD 57454

Charles and Dolores Zammert
Rt. 1, Box 93
Euclid, MN 56722

7. BIBLIOGRAPHY

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8. INDEX

To be added prior to final printing.